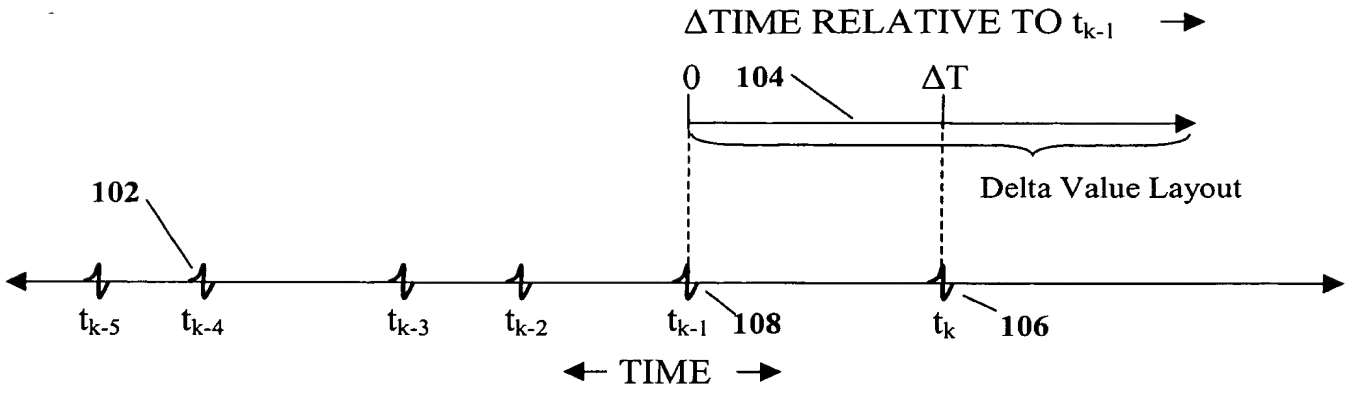


FIGURE 1. Temporal Characteristic Delta Value Layout

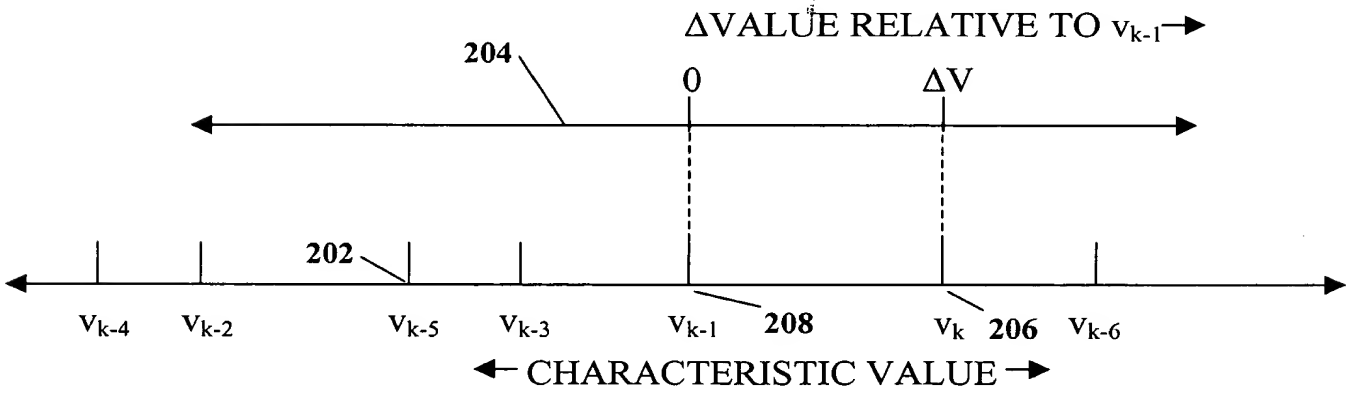


FIGURE 2. Non-temporal Characteristic Delta Value Layout

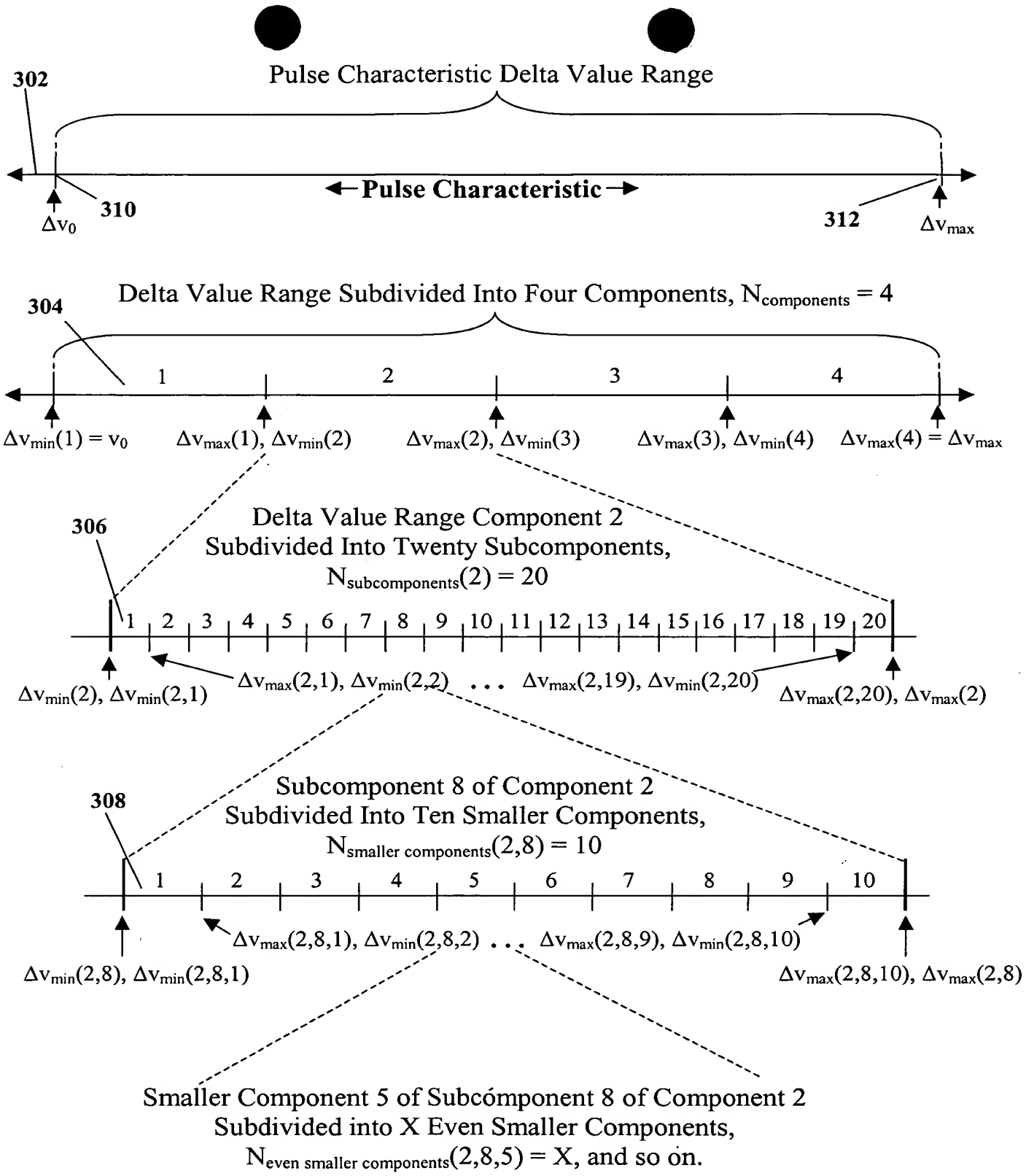


FIGURE 3. Characteristic Delta Value Range Layout Parameters

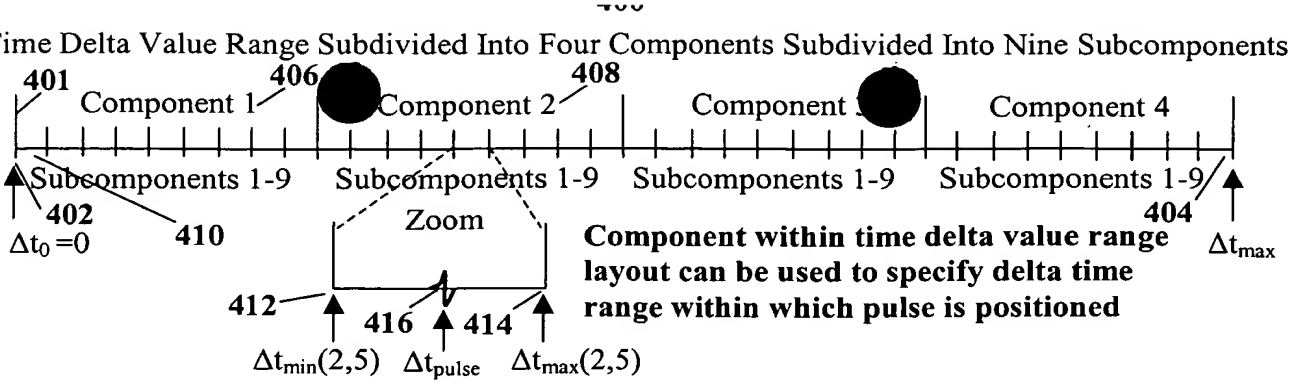


FIGURE 4a.

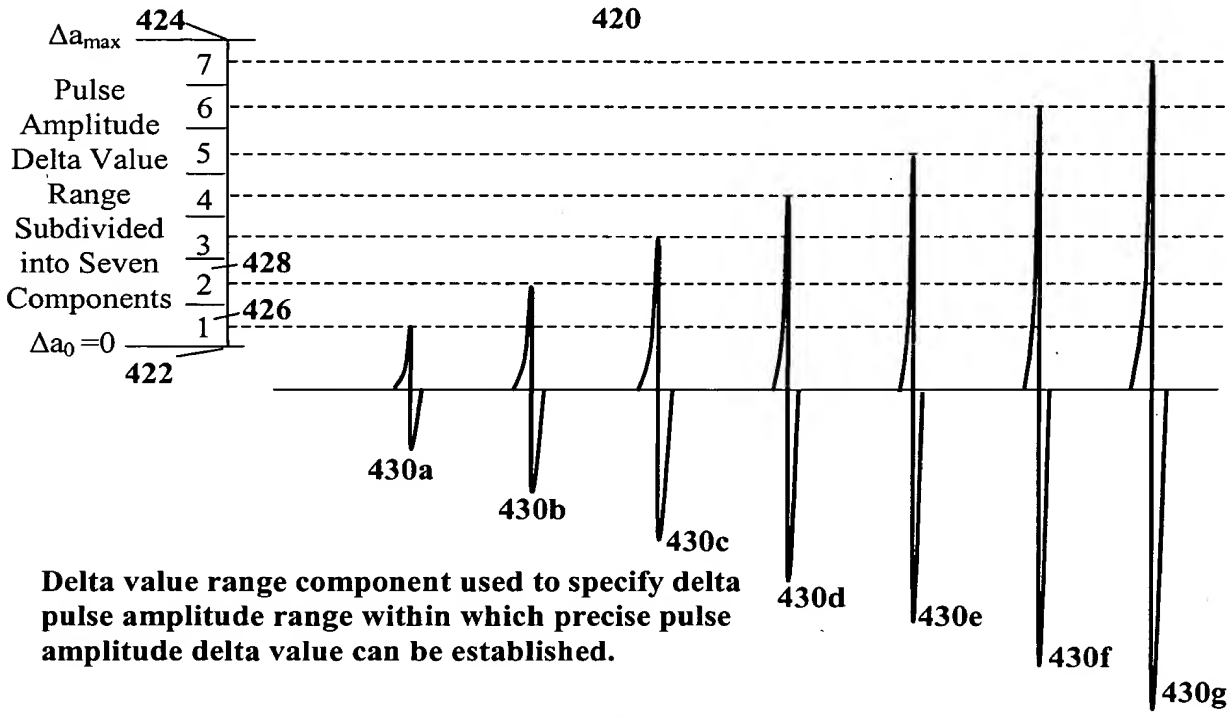


FIGURE 4b

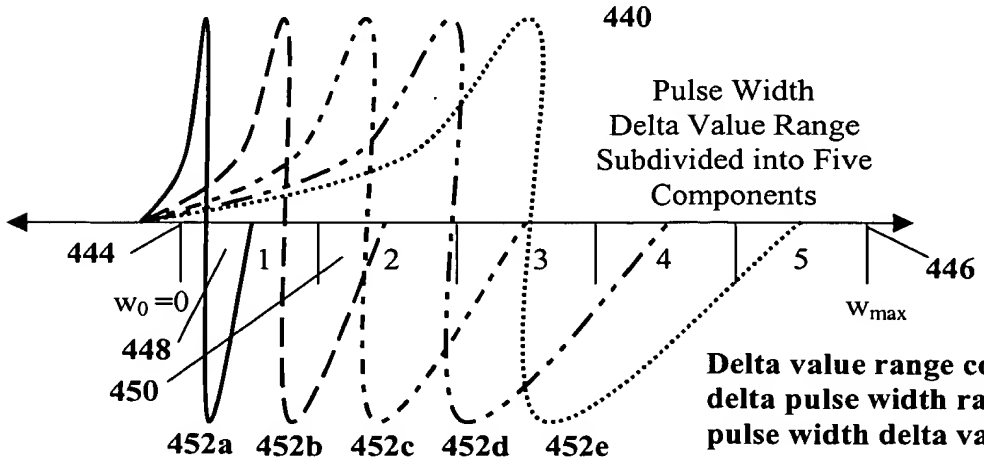


FIGURE 4c

Non-Allowable Regions Within Delta Value Range Layout

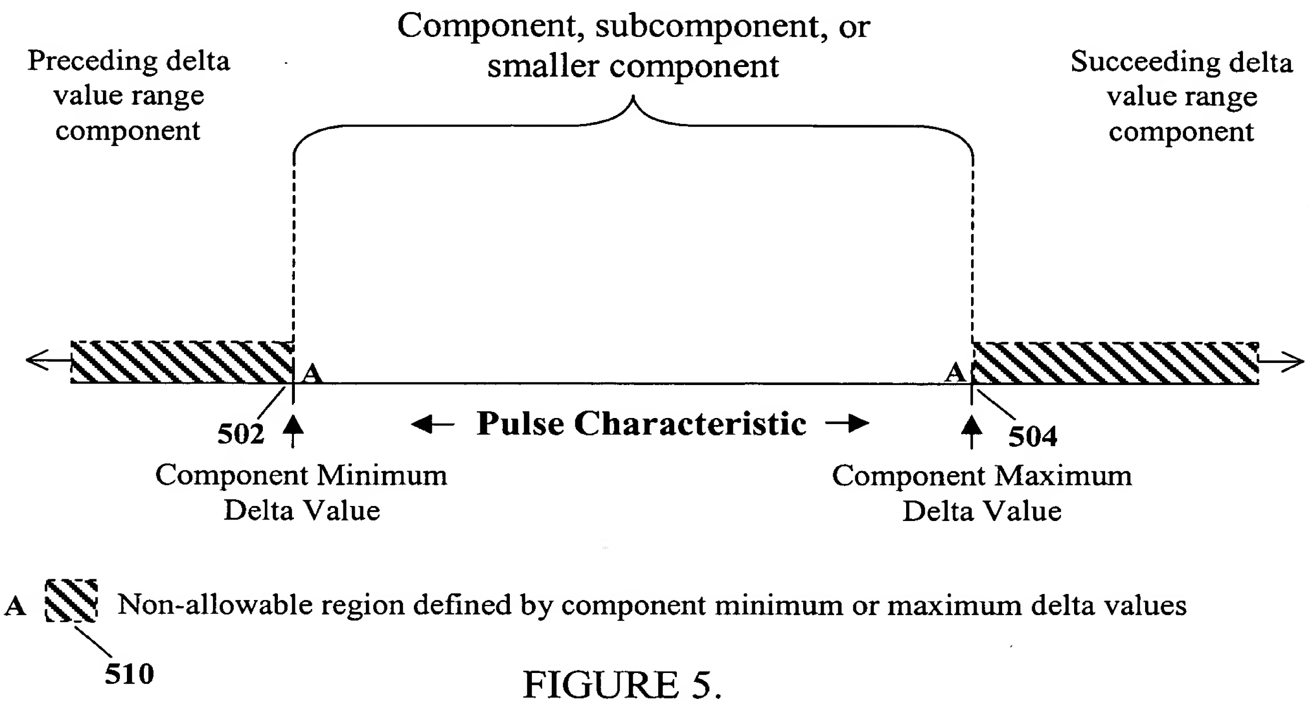
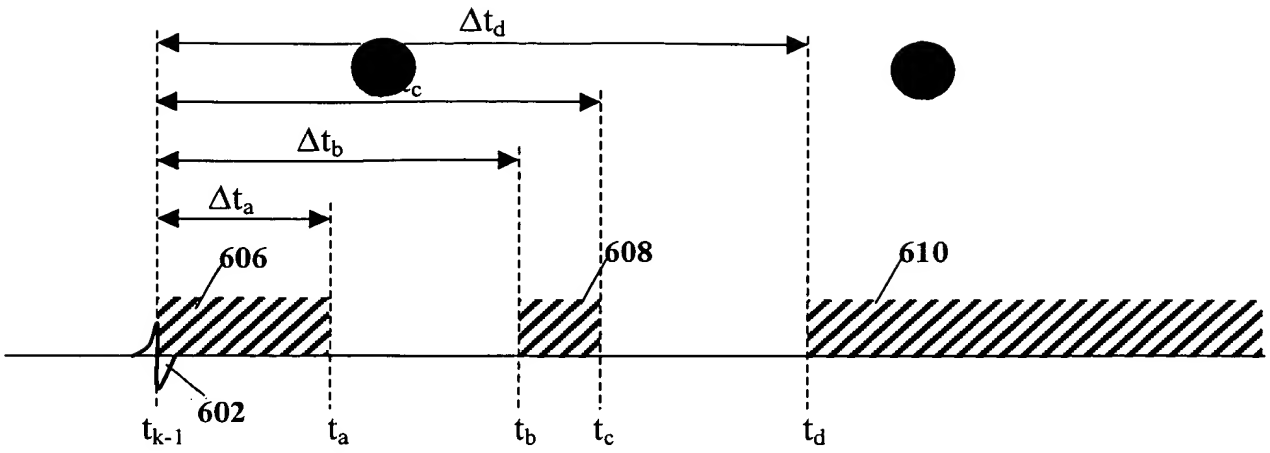


FIGURE 5.

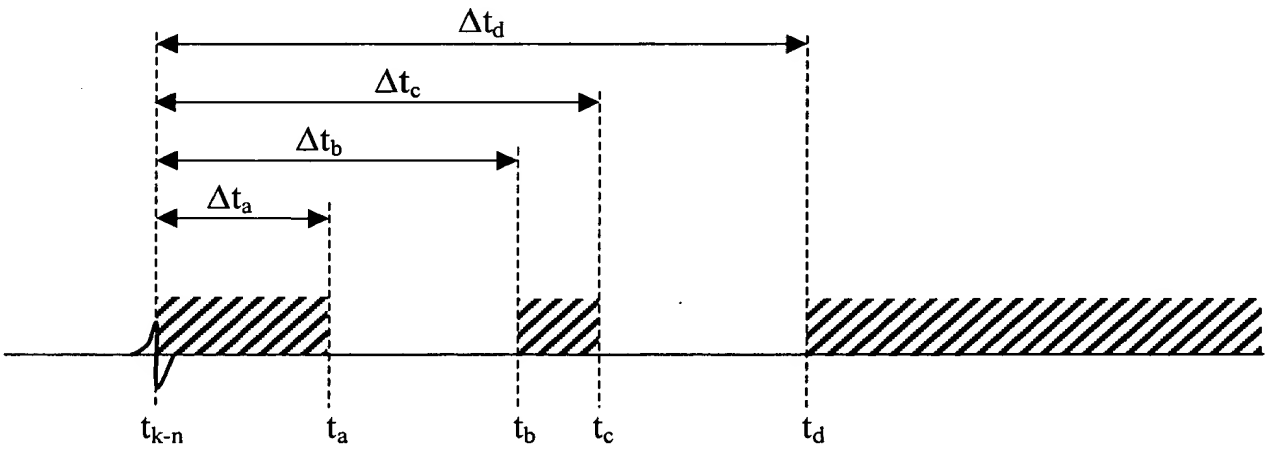


$\Delta t_k \notin [0, \Delta t_a]$, $t_k \notin [t_{k-1}, t_a]$ where $t_a - t_{k-1} = \Delta t_{min}$

$\Delta t_k \notin [\Delta t_b, \Delta t_c]$, $t_k \notin [t_b, t_c]$

$\Delta t_k \notin [\Delta t_d, \infty]$, $t_k \notin [t_d, \infty]$ where $t_d - t_{k-1} = \Delta t_{max}$

FIGURE 6a. Non-allowable Regions Relative to Preceding Pulse Position

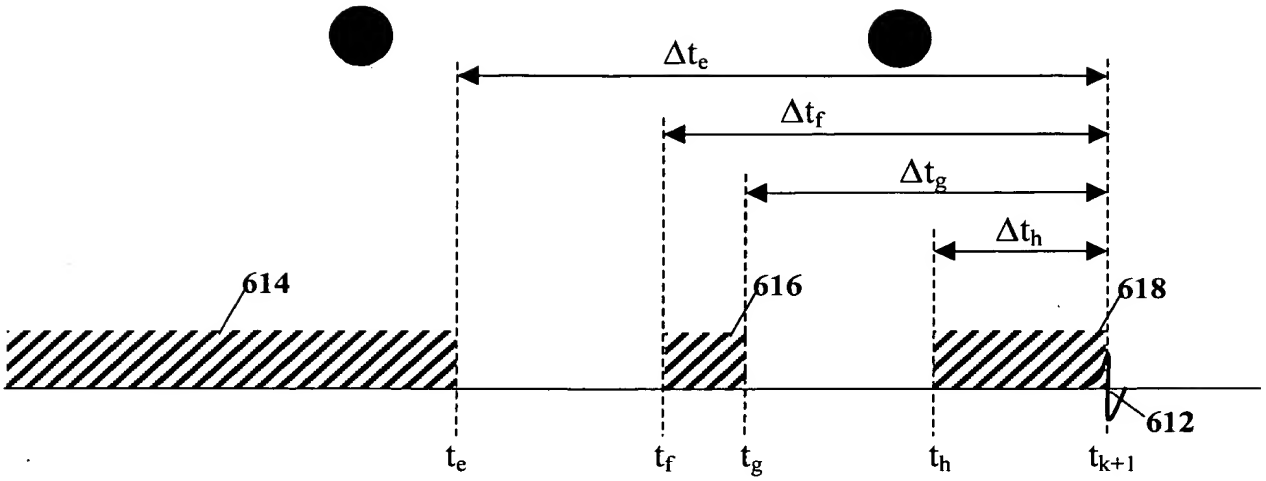


$\Delta t_k \notin [0, \Delta t_a]$, $t_k \notin [t_{k-n}, t_a]$ where $t_a - t_{k-n} = \Delta t_{min}$

$\Delta t_k \notin [\Delta t_b, \Delta t_c]$, $t_k \notin [t_b, t_c]$

$\Delta t_k \notin [\Delta t_d, \infty]$, $t_k \notin [t_d, \infty]$ where $t_d - t_{k-n} = \Delta t_{max}$

FIGURE 6b. Non-allowable Regions Relative to Any Preceding Pulse Position

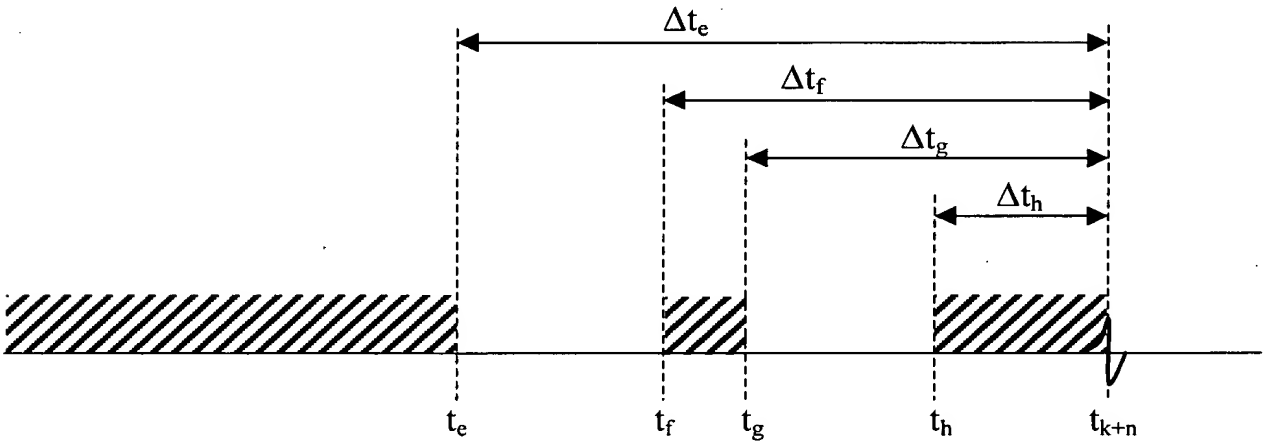


$\Delta t_k \notin [-\Delta t_h, 0]$, $t_k \notin [t_h, t_{k+1}]$ where $t_{k+1} - t_h = \Delta t_{min}$

$\Delta t_k \notin [-\Delta t_f, -\Delta t_g]$, $t_k \notin [t_f, t_g]$

$\Delta t_k \notin [-\infty, -\Delta t_e]$, $t_k \notin [-\infty, t_e,]$ where $t_{k+1} - t_e = \Delta t_{max}$

FIGURE 6c. Non-allowable Regions Relative to Succeeding Pulse Position

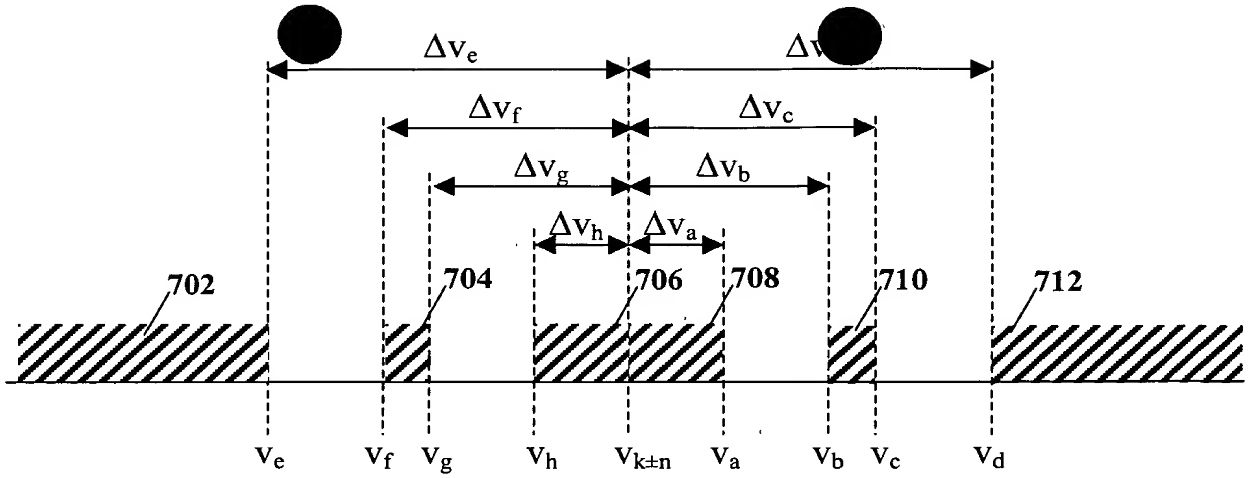


$\Delta t_k \notin [-\Delta t_h, 0]$, $t_k \notin [t_h, t_{k+n}]$ where $t_{k+n} - t_h = \Delta t_{min}$

$\Delta t_k \notin [-\Delta t_f, -\Delta t_g]$, $t_k \notin [t_f, t_g]$

$\Delta t_k \notin [-\infty, -\Delta t_e]$, $t_k \notin [-\infty, t_e,]$ where $t_{k+n} - t_e = \Delta t_{max}$

FIGURE 6d. Non-allowable Regions Relative to Any Succeeding Pulse Position



$\Delta v_k \notin [-\infty, -\Delta v_e]$, $\quad v_k \notin [-\infty, v_e]$ $\quad$ where $v_{k\pm n} - v_e = \Delta v_{max}$

$\Delta v_k \notin [-\Delta v_f, -\Delta v_g]$, $\quad v_k \notin [v_f, v_g]$

$\Delta v_k \notin [-\Delta v_h, 0]$, $\quad v_k \notin [v_h, v_{k\pm n}]$ $\quad$ where $v_{k\pm n} - v_h = \Delta v_{min}$

$\Delta v_k \notin [0, \Delta v_a]$, $\quad v_k \notin [v_{k\pm n}, v_a]$ $\quad$ where $v_a - v_{k\pm n} = \Delta v_{min}$

$\Delta v_k \notin [\Delta v_b, \Delta v_c]$, $\quad v_k \notin [v_b, v_c]$

$\Delta v_k \notin [\Delta v_d, \infty]$, $\quad v_k \notin [v_d, \infty]$ $\quad$ where $v_d - v_{k\pm n} = \Delta v_{max}$

FIGURE 7. Non-allowable Regions Relative to Characteristic Value of Any Other Pulse

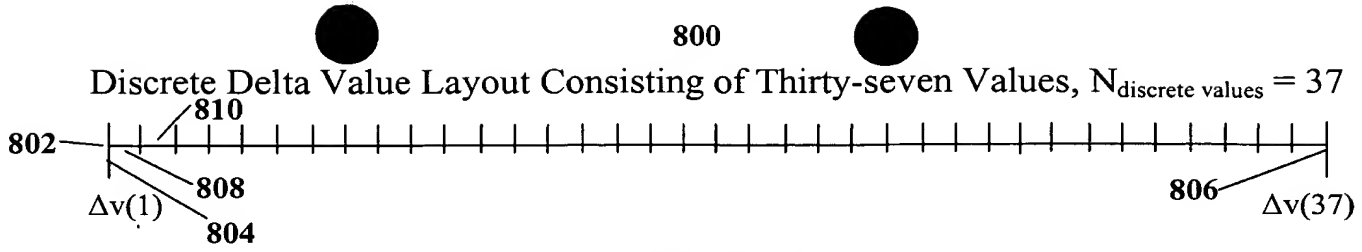


FIGURE 8a.

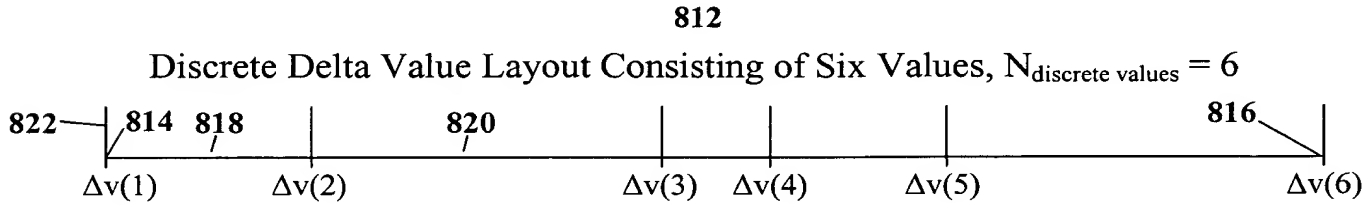


FIGURE 8b.

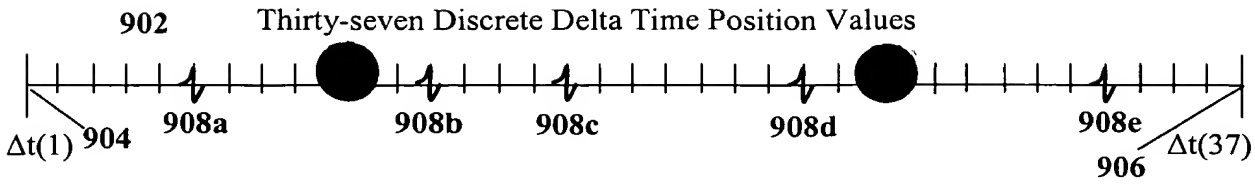


FIGURE 9a.

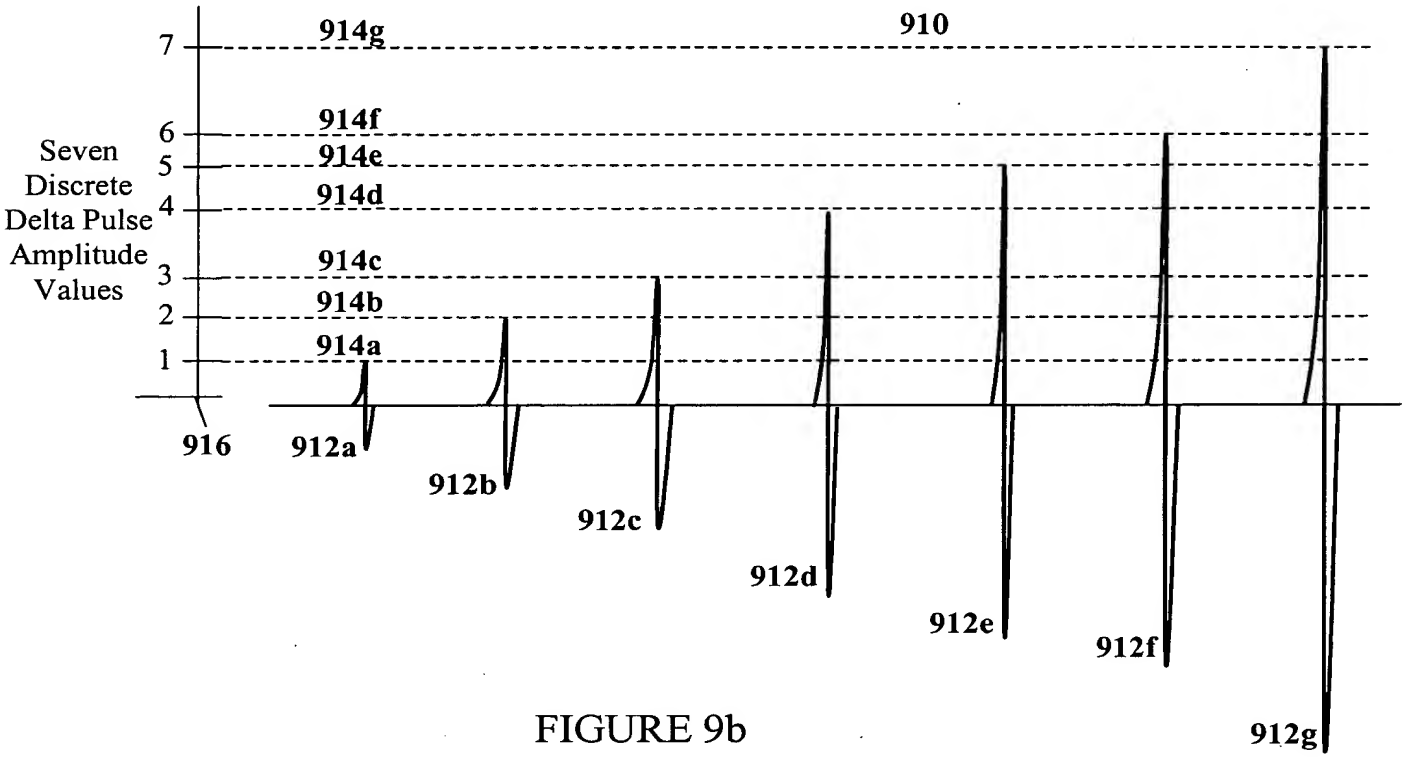


FIGURE 9b

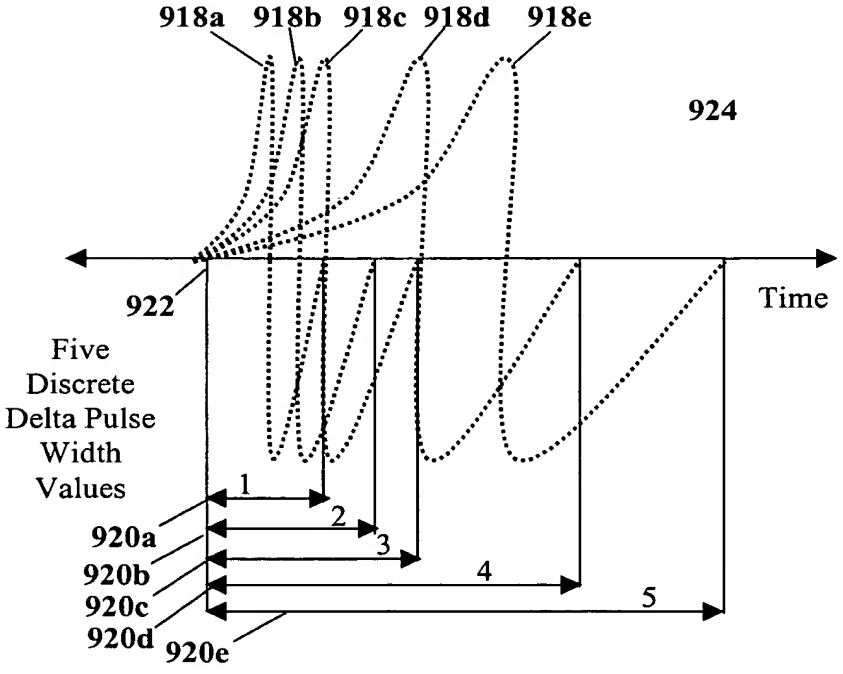


FIGURE 9c

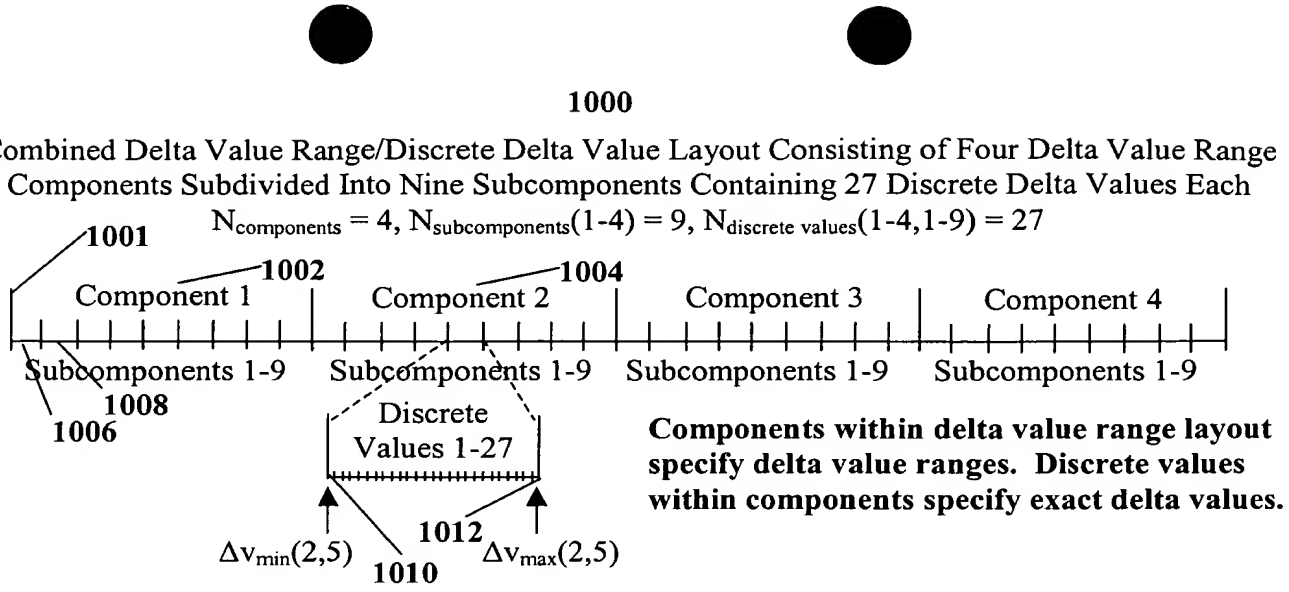


FIGURE 10.

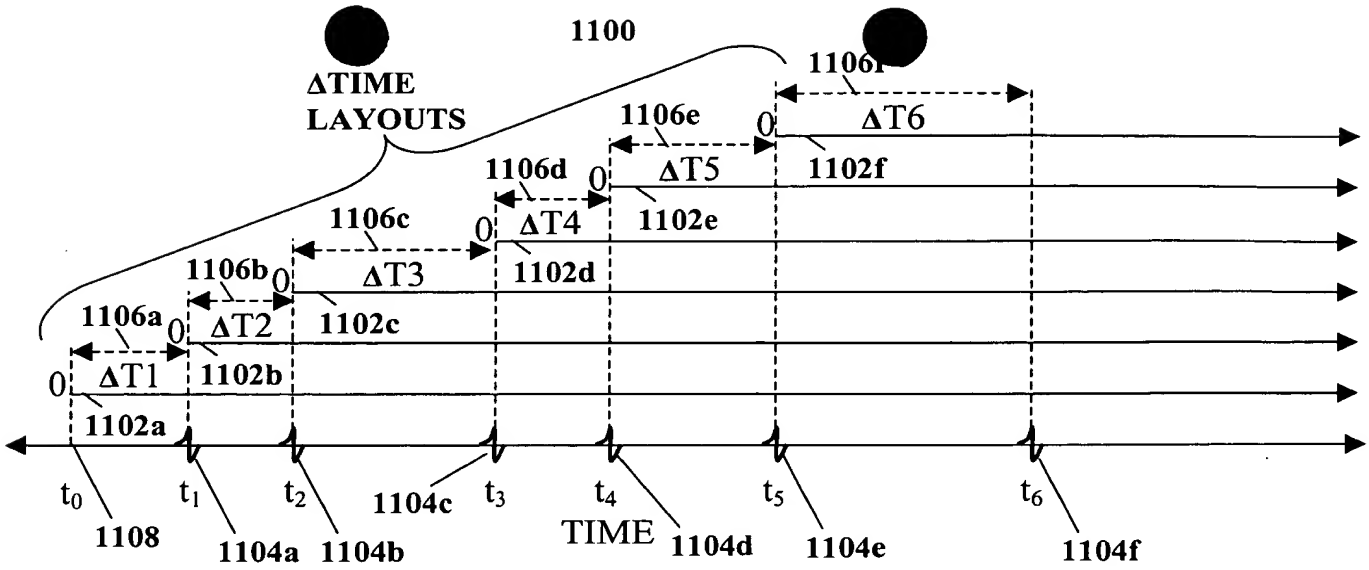


FIGURE 11a. Single Code Element Per Reference Temporal Delta Coding

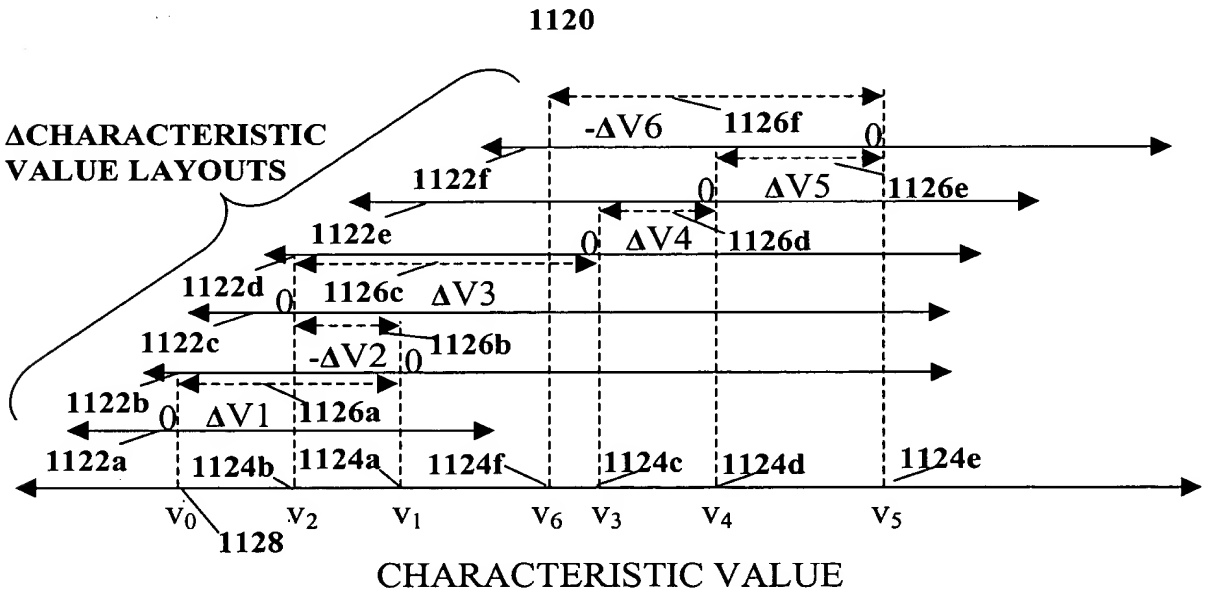


FIGURE 11b. Single Code Element Per Reference Non-temporal Delta Coding

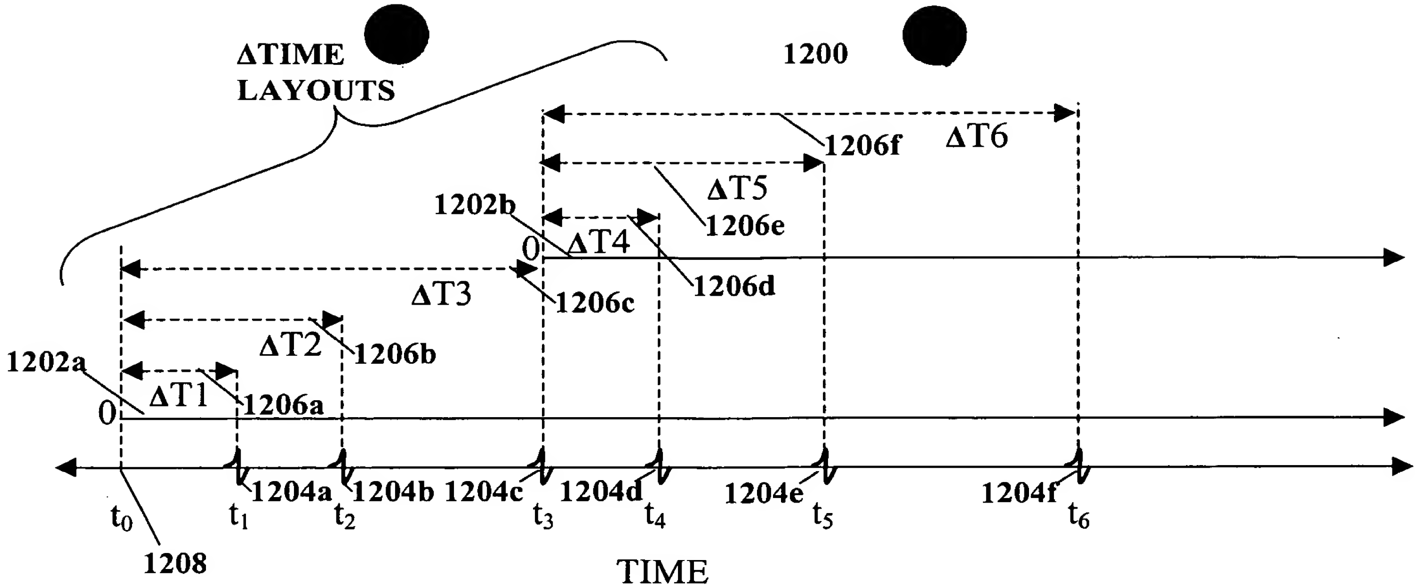


FIGURE 12a. Multiple (3) Code Elements Per Reference Temporal Delta Coding

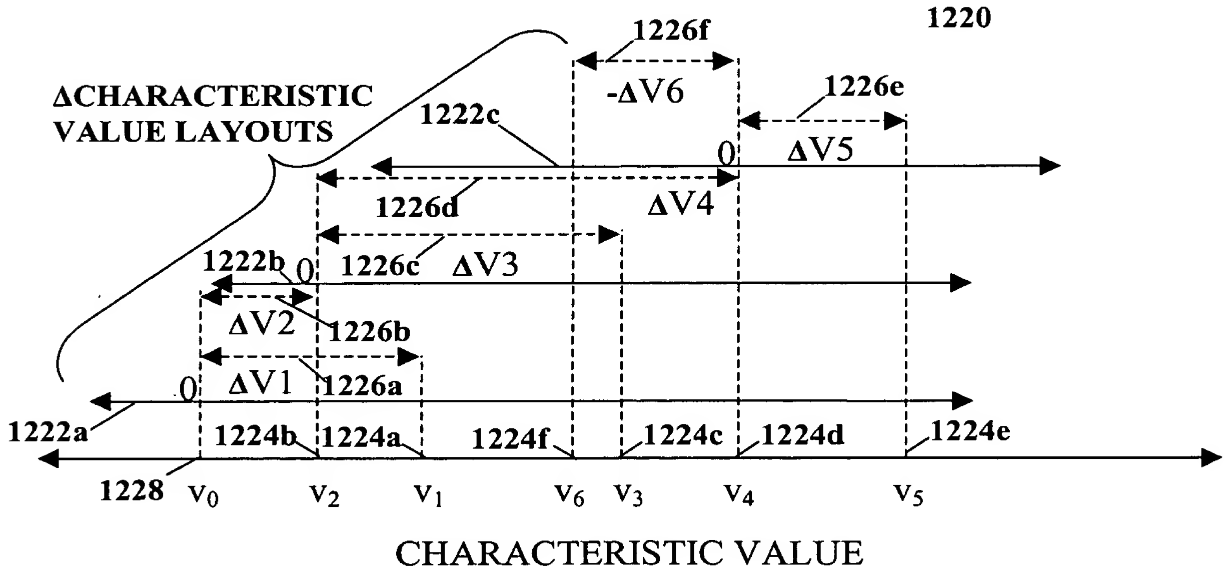


FIGURE 12b. Multiple (2) Code Elements Per Reference Non-temporal Delta Coding

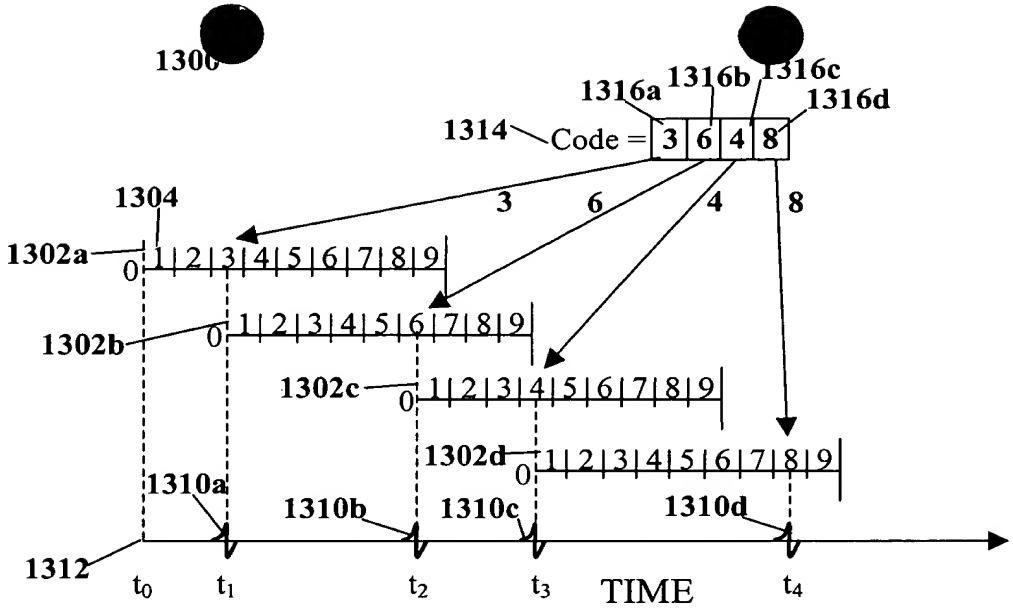


FIGURE 13a

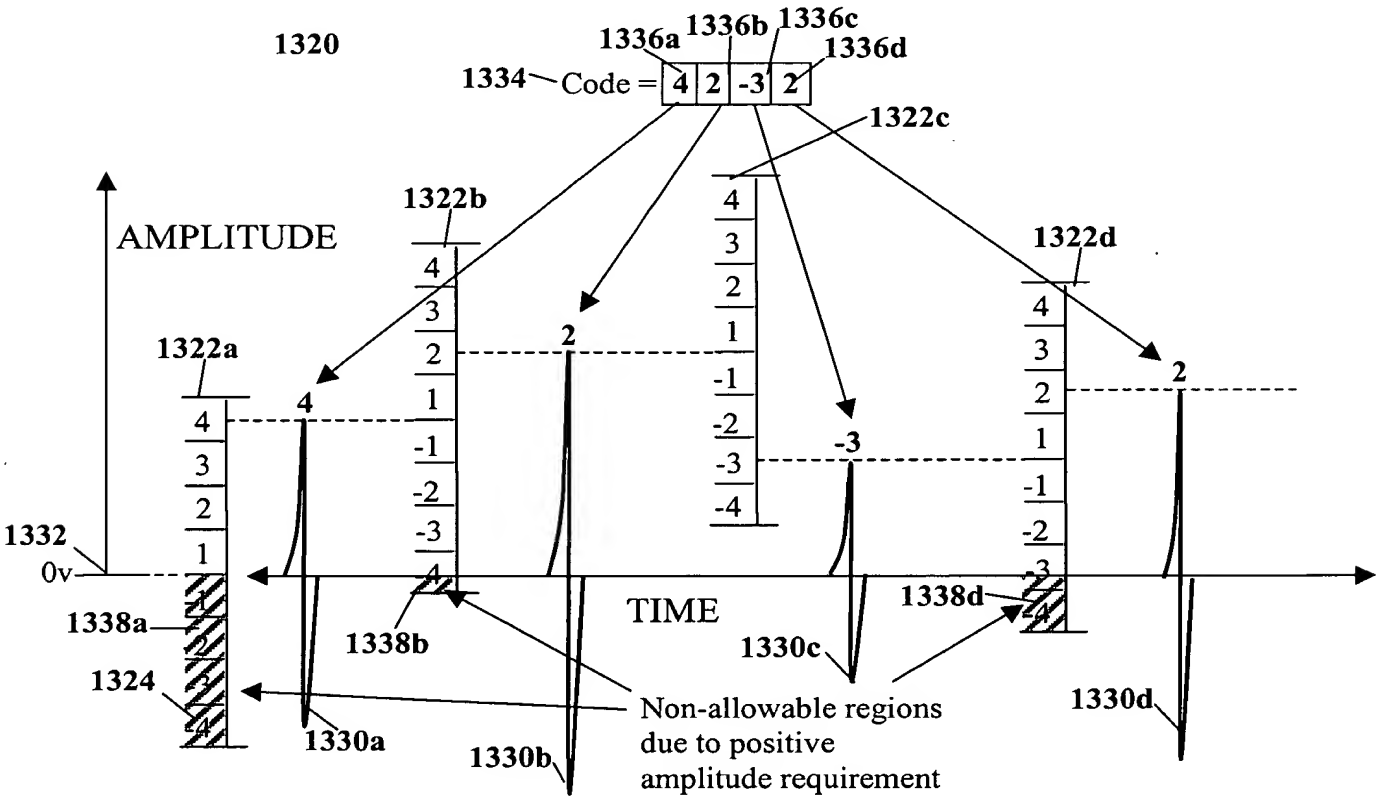


FIGURE 13b

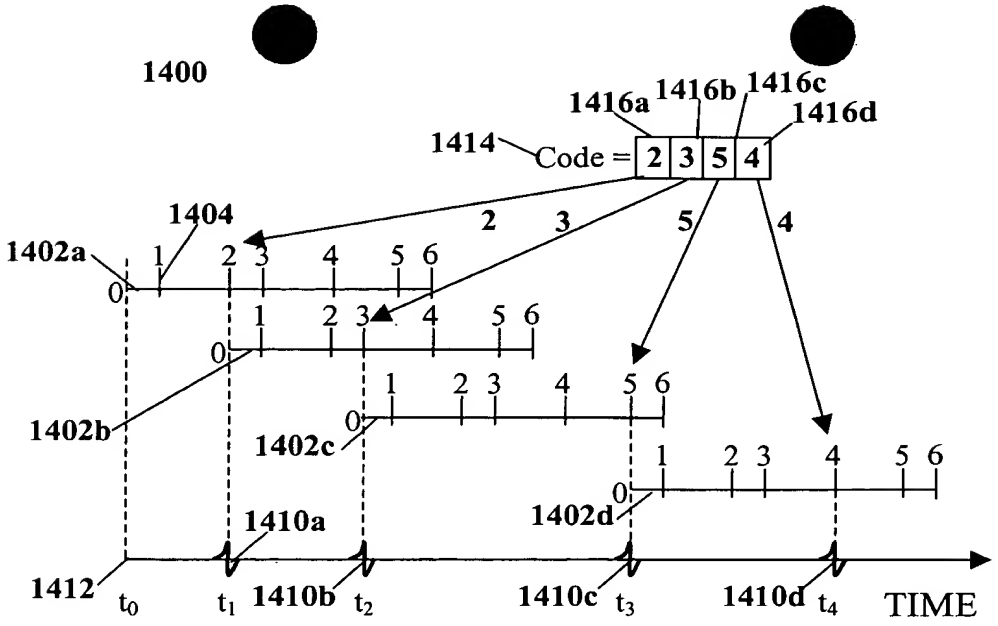


FIGURE 14a

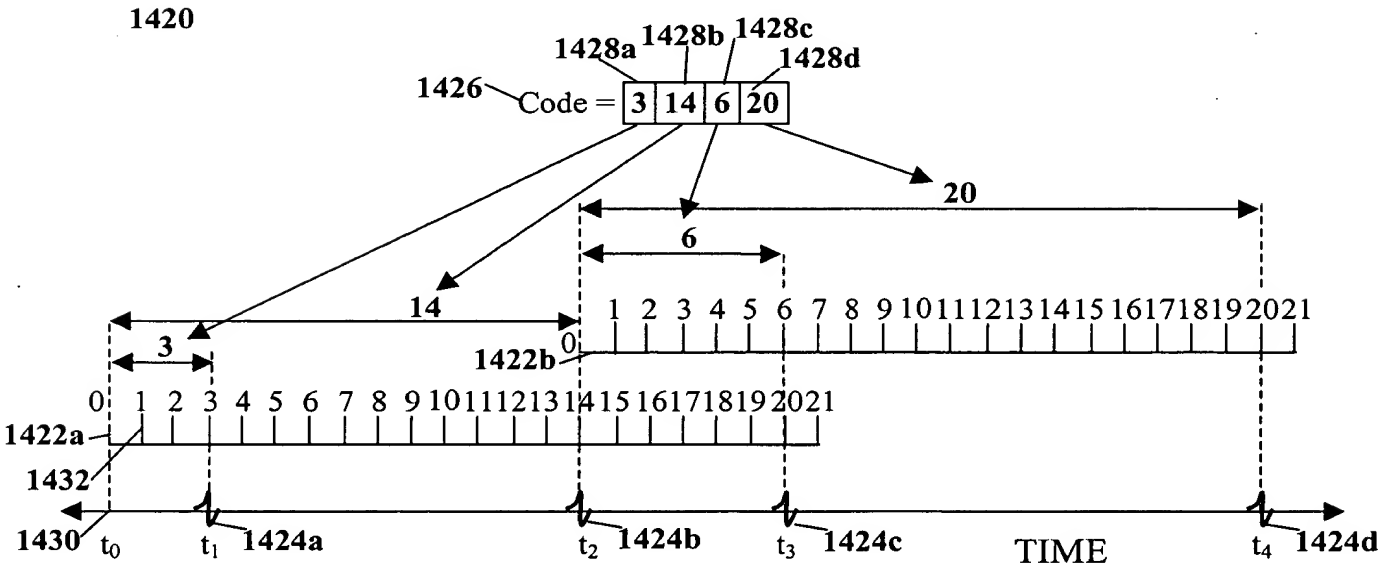


FIGURE 14b

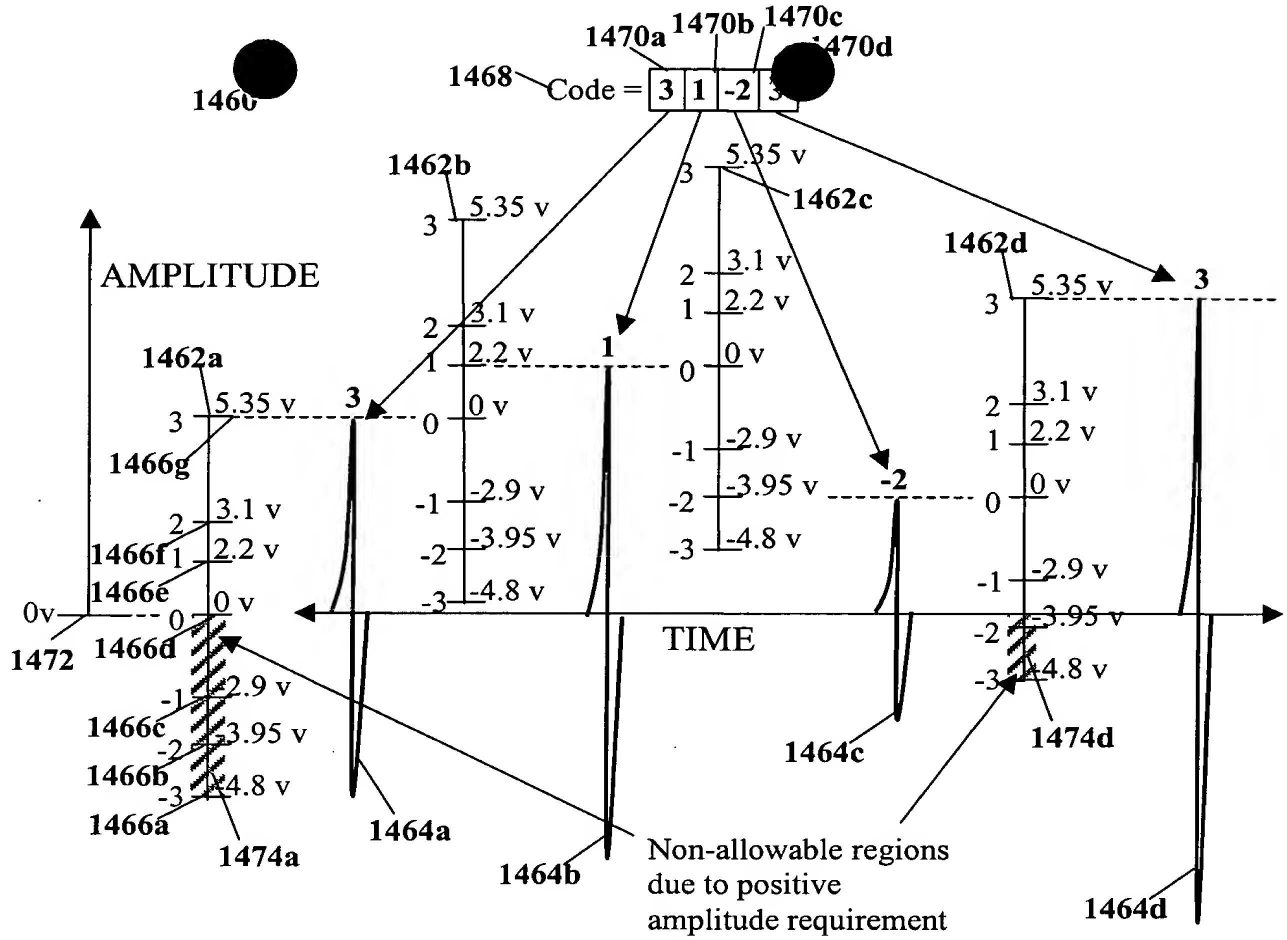


FIGURE 14c

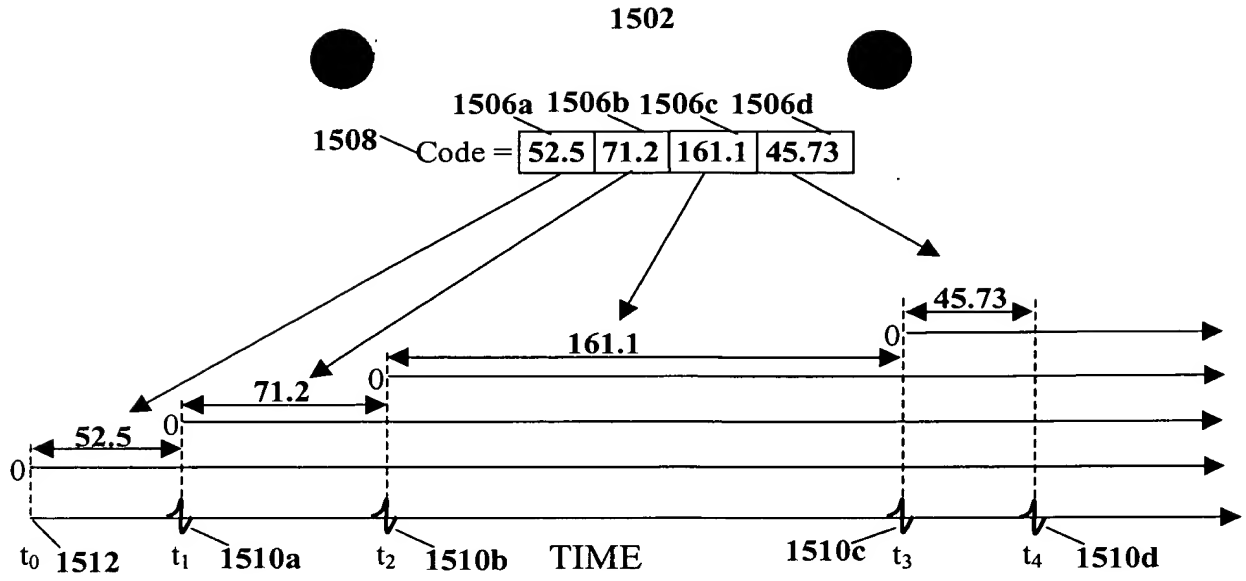


FIGURE 15a

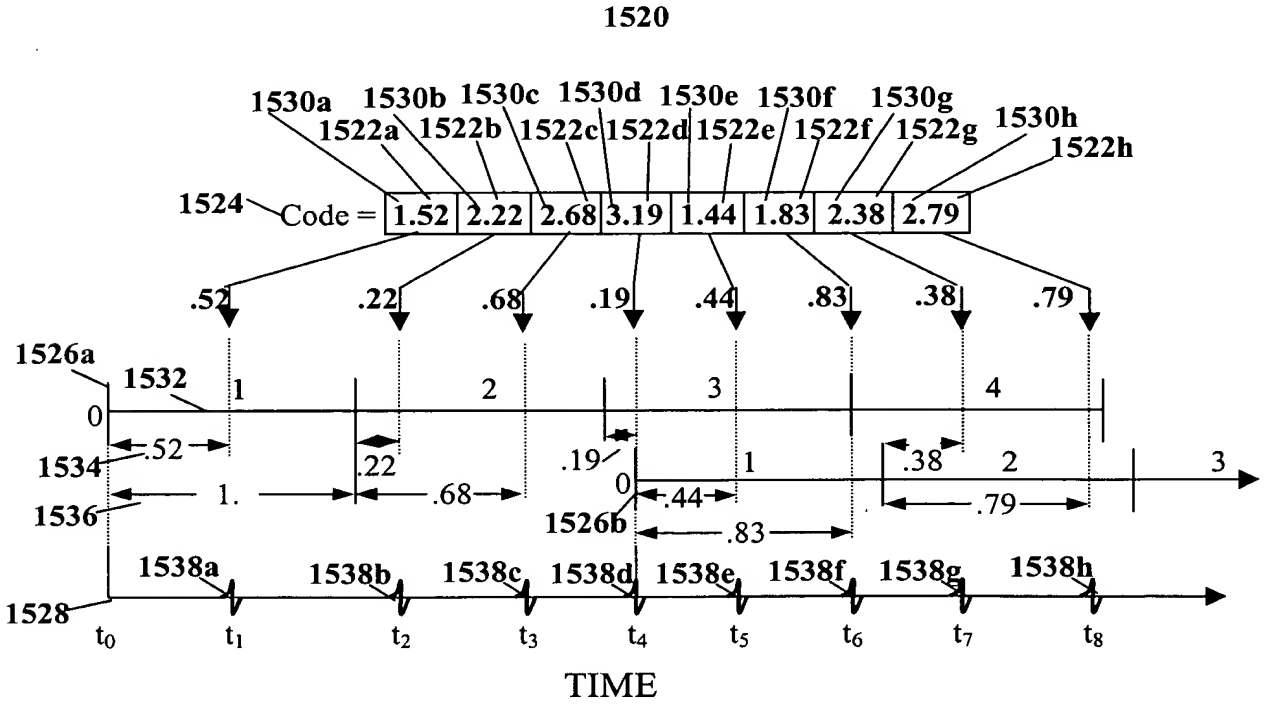


FIGURE 15b

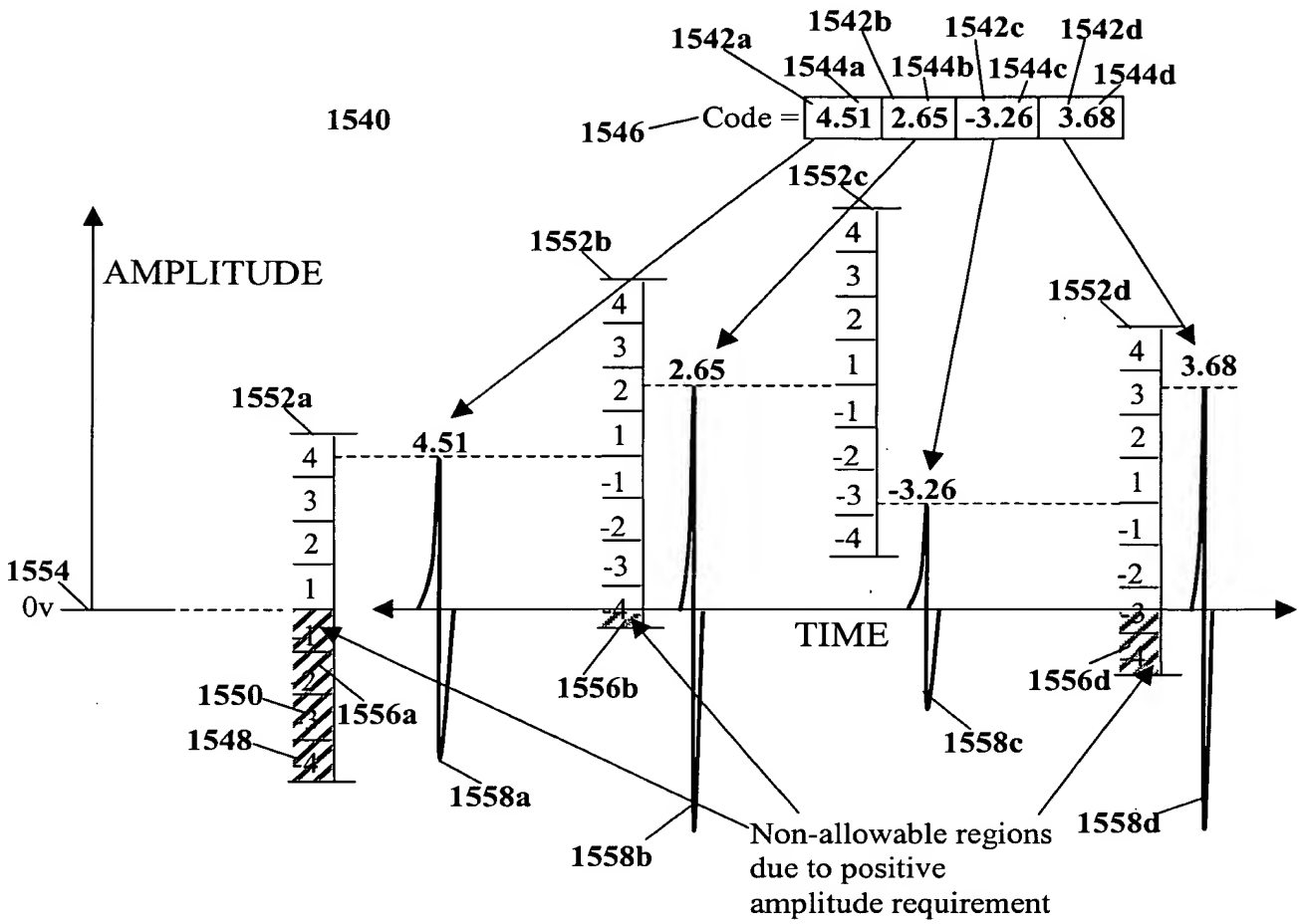
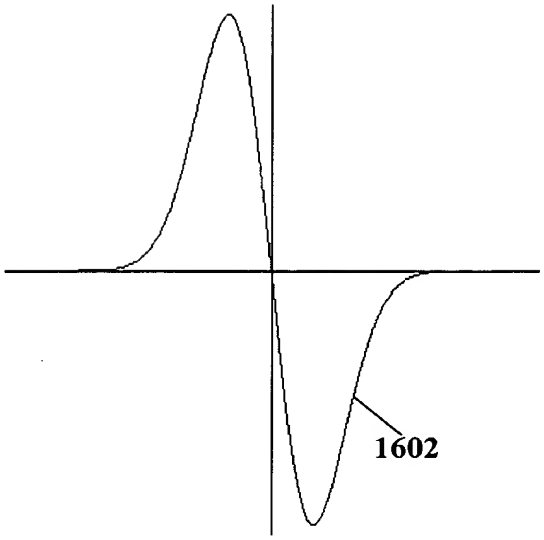
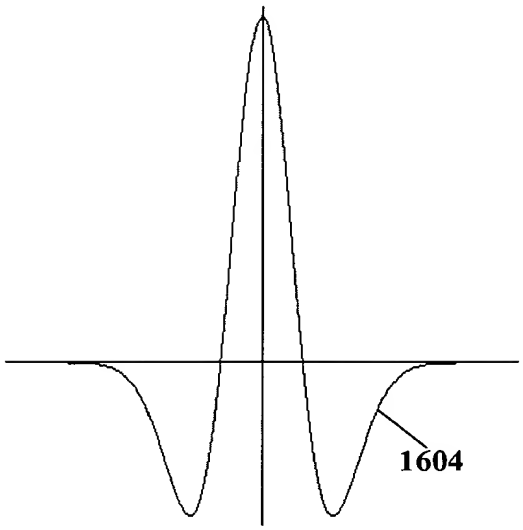

1542a
1542b
1542c
1542d
1544a
1544b
1544c
1544d
1540
1546
Code =
4.51
2.65
-3.26
3.68
1552c
1552b
1552d
AMPLITUDE
1552a
2.65
3.68
4.51
-3.26
1554
0v
TIME
1550
1556a
1548
1556b
1556d
1558a
1558c
1558d
1558b
Non-allowable regions due to positive amplitude requirement

FIGURE 15c



Pulse Doublet

FIGURE 16a



Pulse Triplet

FIGURE 16b

Typical Time-Coded UWB Pulse Trains

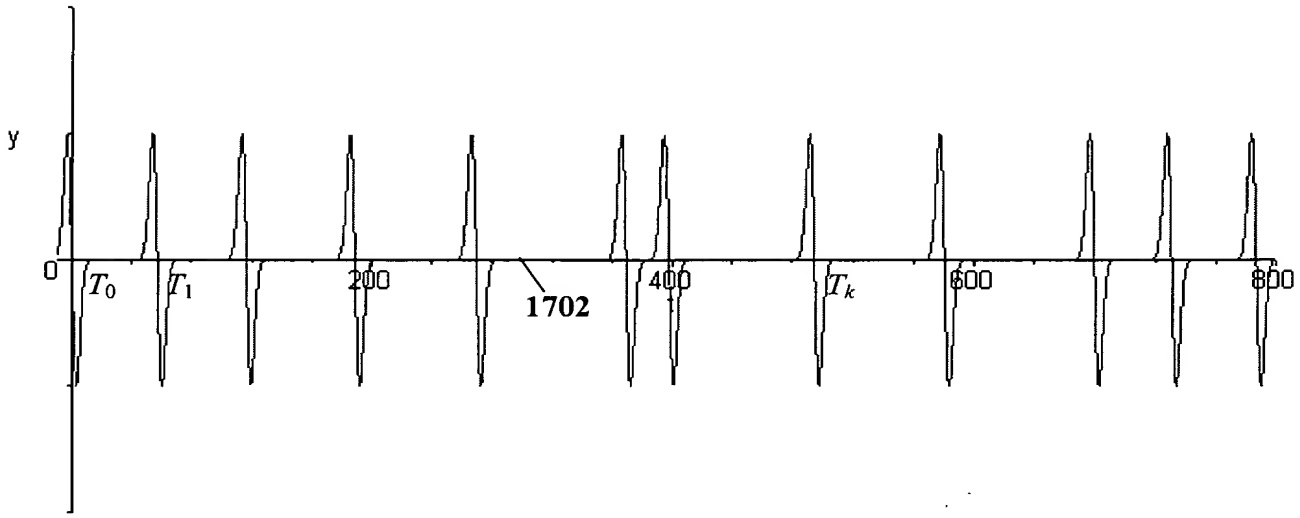


FIGURE 17a

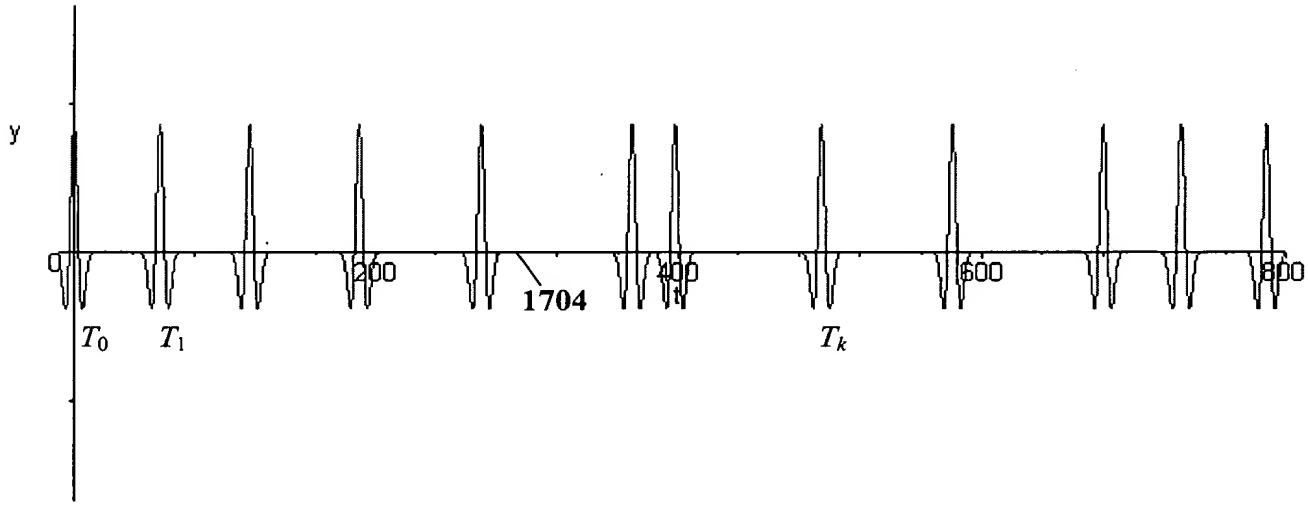


FIGURE 17b

Exponential Probability Density Functions

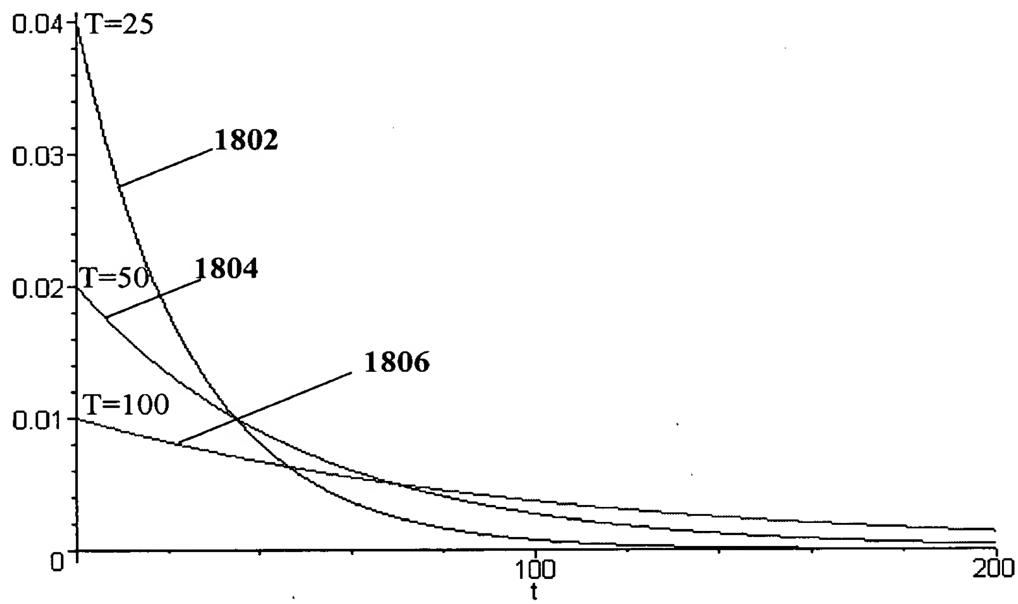


FIGURE 18

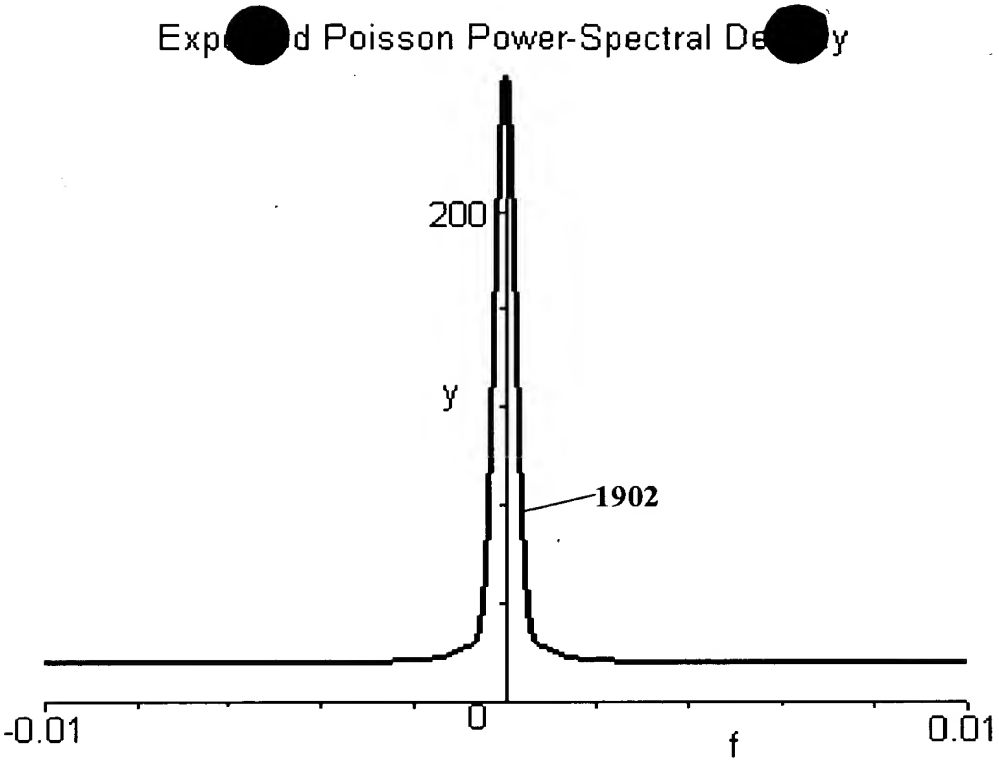


FIGURE 19

Power Spectral Density for a Poisson Code (1 of 3)

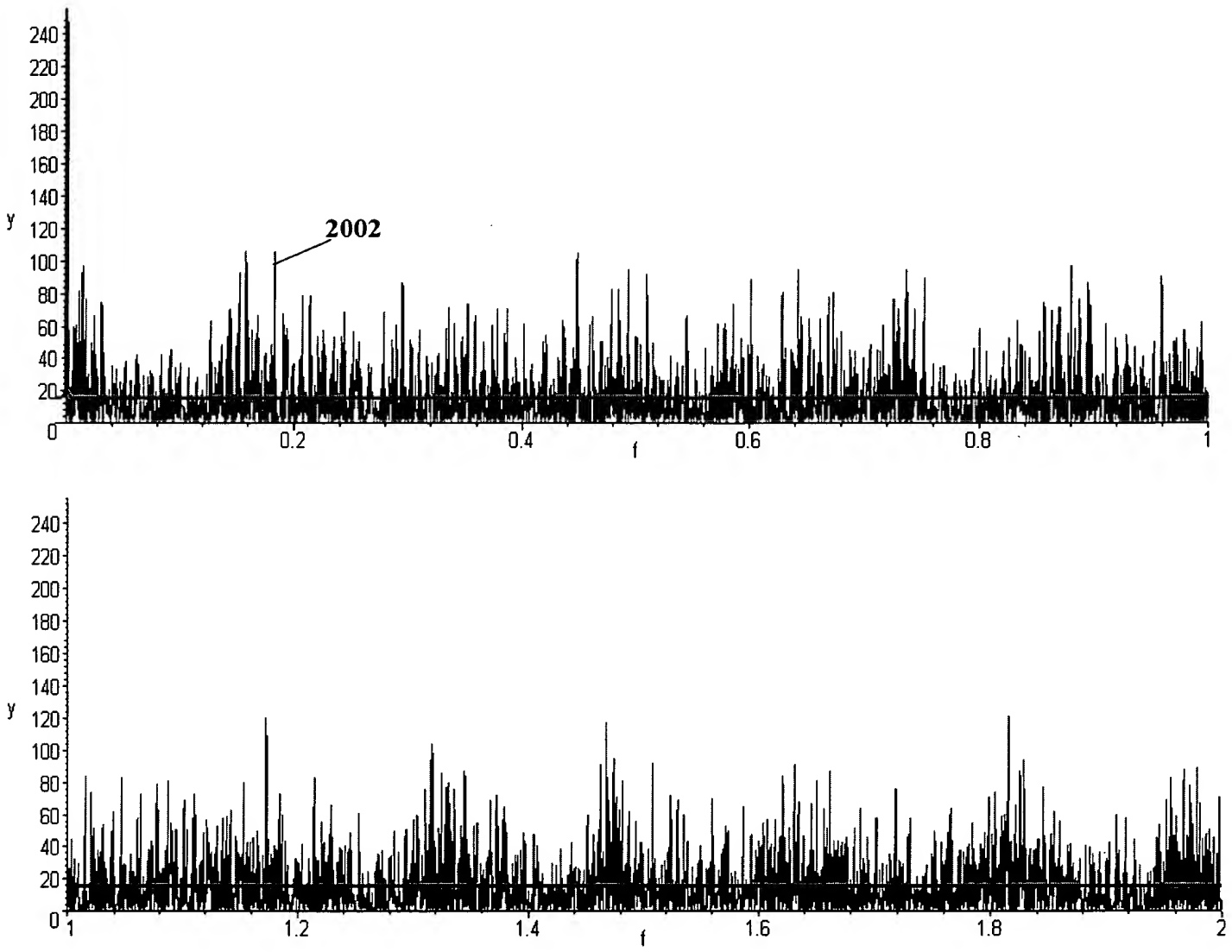


FIGURE 20a

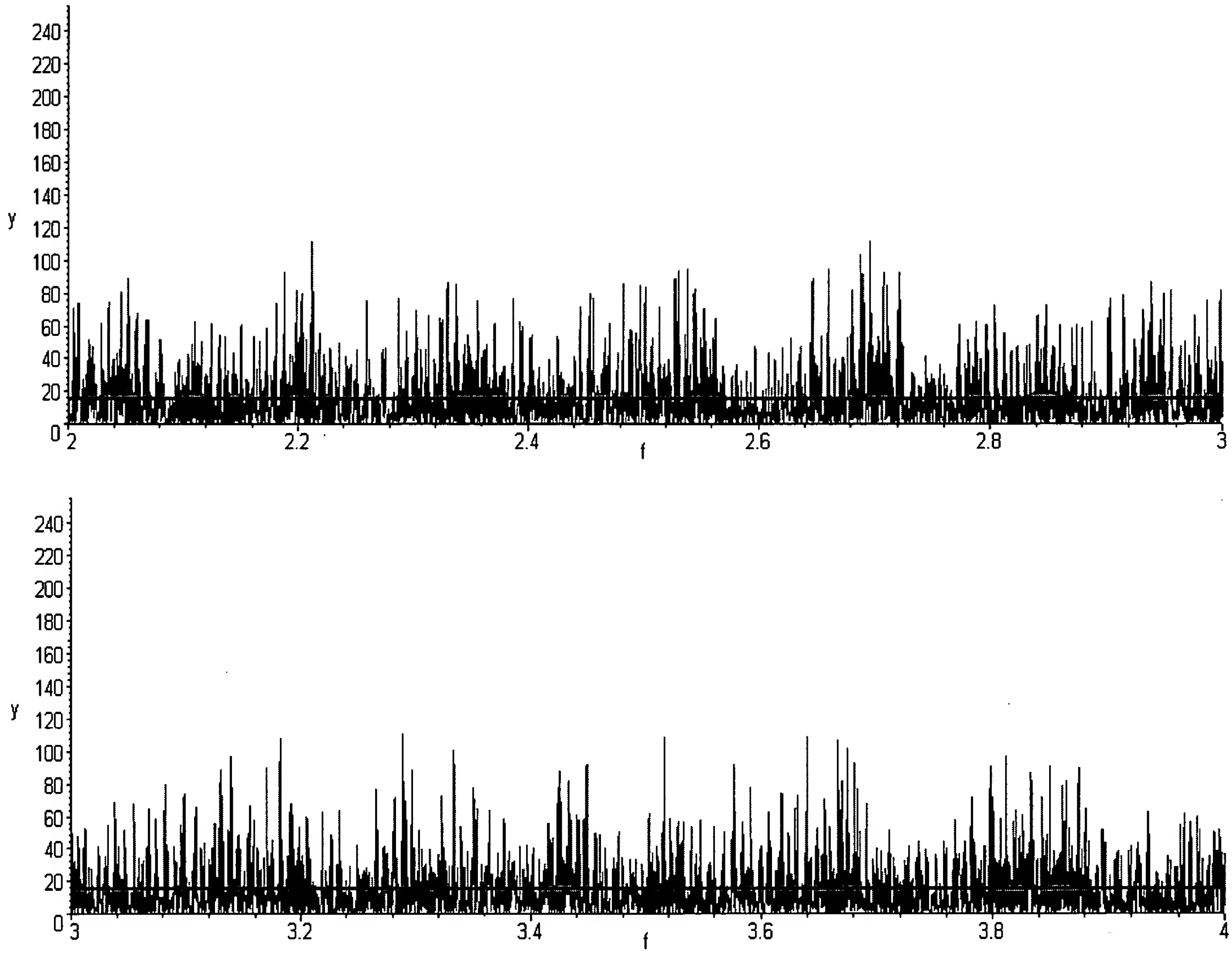


FIGURE 20b

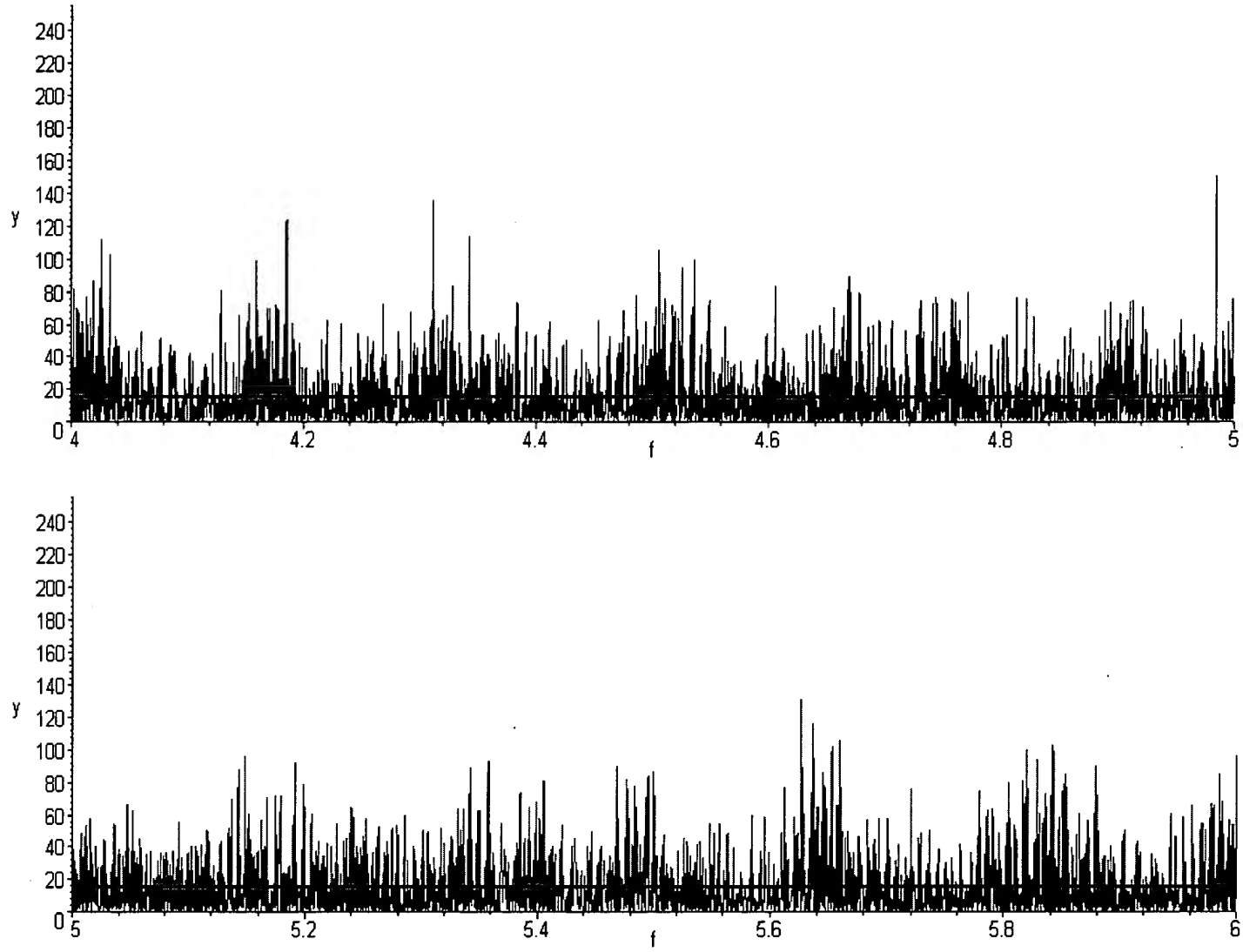

y
f
0
20
40
60
80
100
120
140
160
180
200
220
240
4
4.2
4.4
4.6
4.8
5
5
5.2
5.4
5.6
5.8
6

FIGURE 20c

Modified Exponential Probability Density Functions

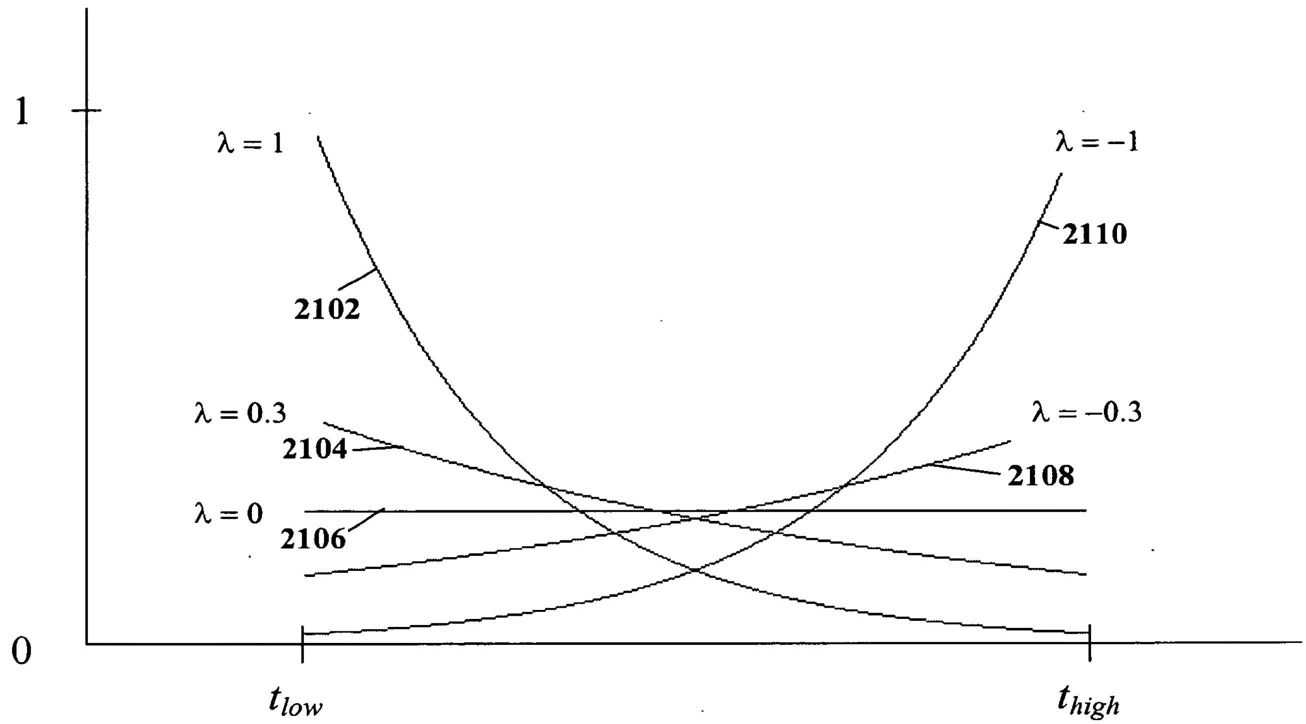


FIGURE 21

Expected Inter-Pulse Time T as a Function of λ

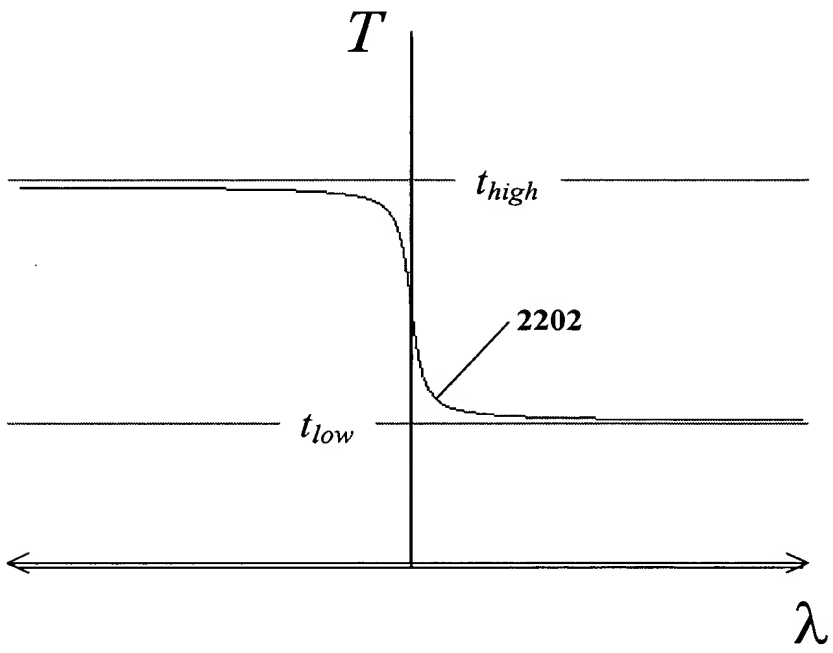


FIGURE 22

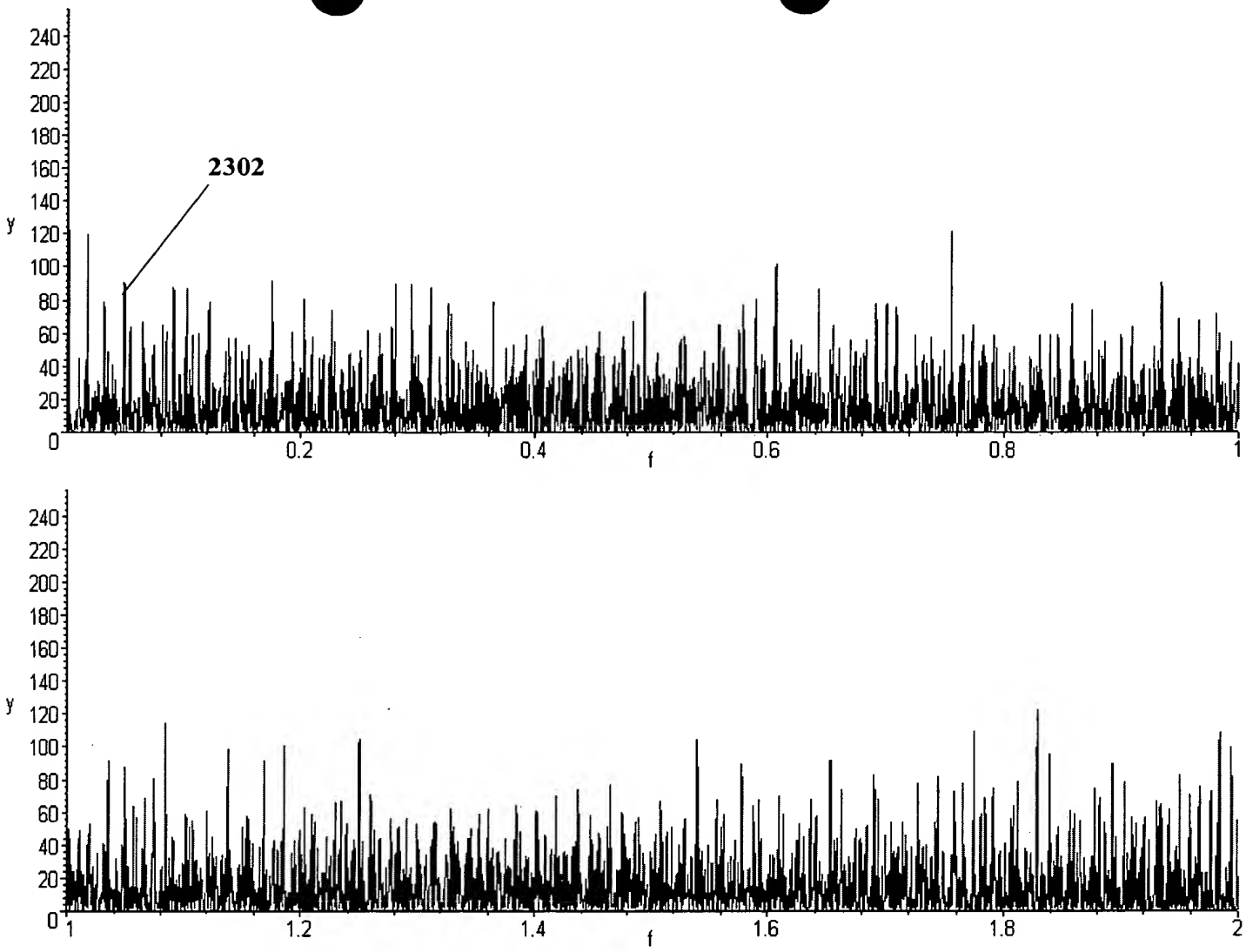

2302
y
f
0
20
40
60
80
100
120
140
160
180
200
220
240
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2

FIGURE 23a

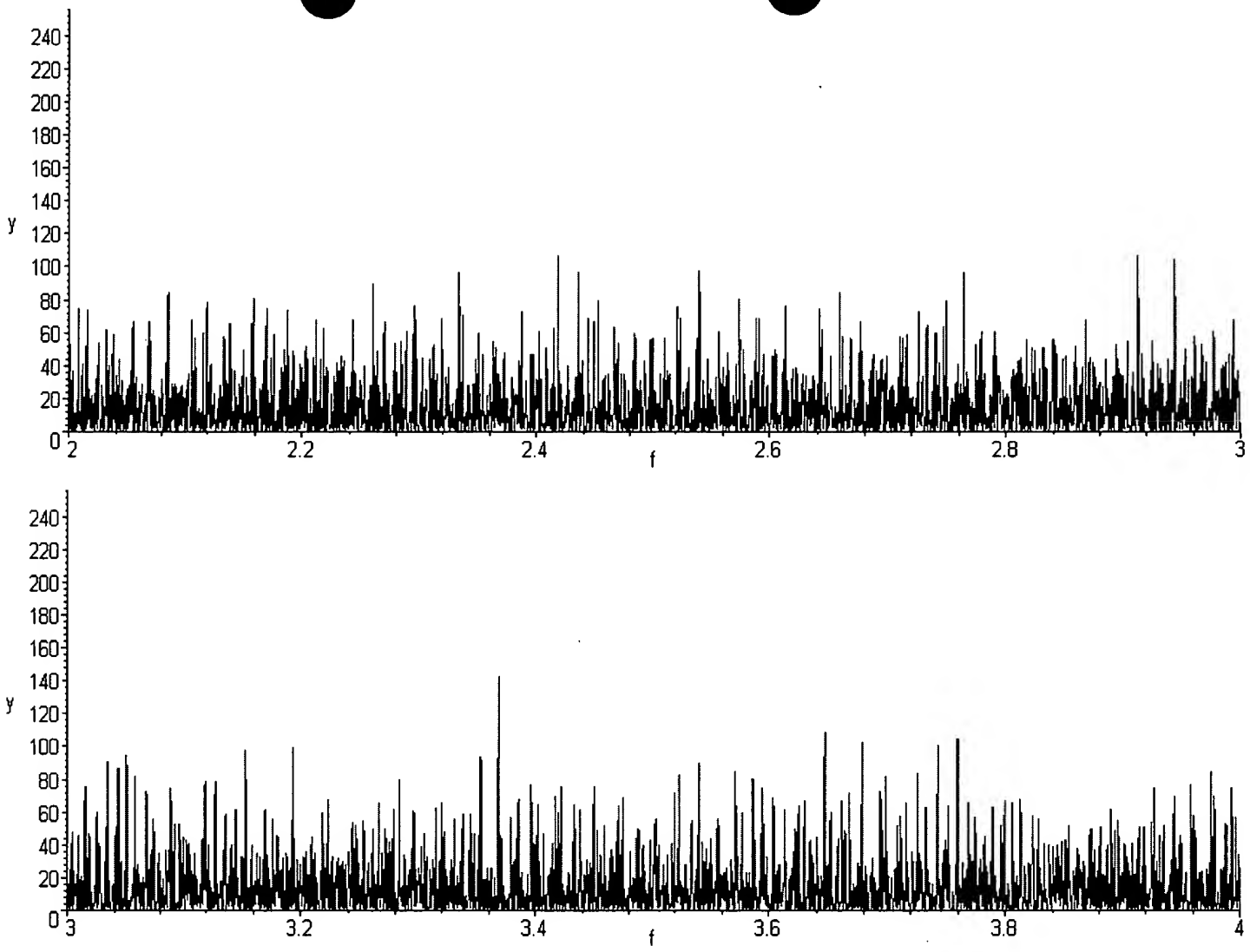

y
f
0
20
40
60
80
100
120
140
160
180
200
220
240
2
2.2
2.4
2.6
2.8
3
3.2
3.4
3.6
3.8
4

FIGURE 23b

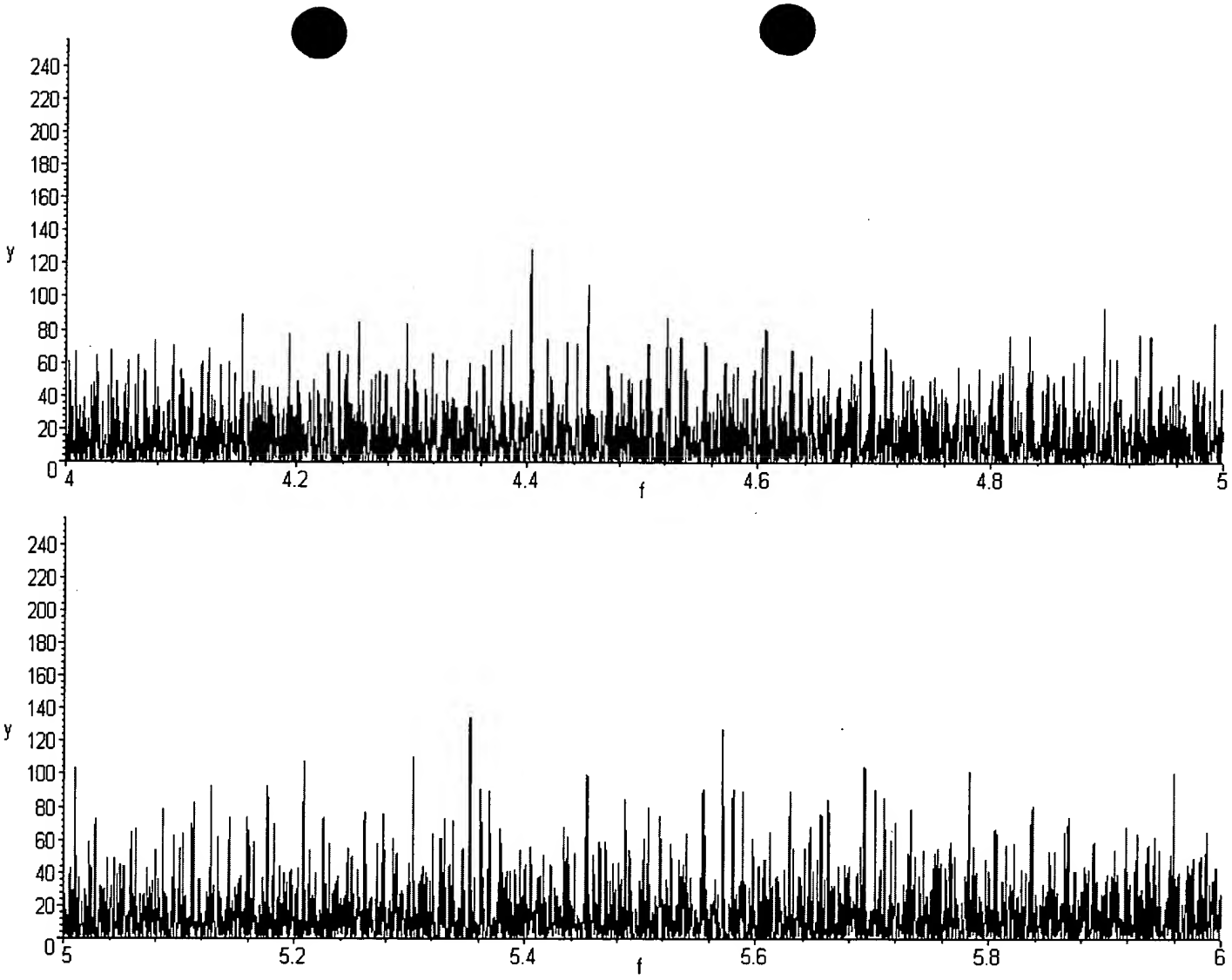


FIGURE 23c

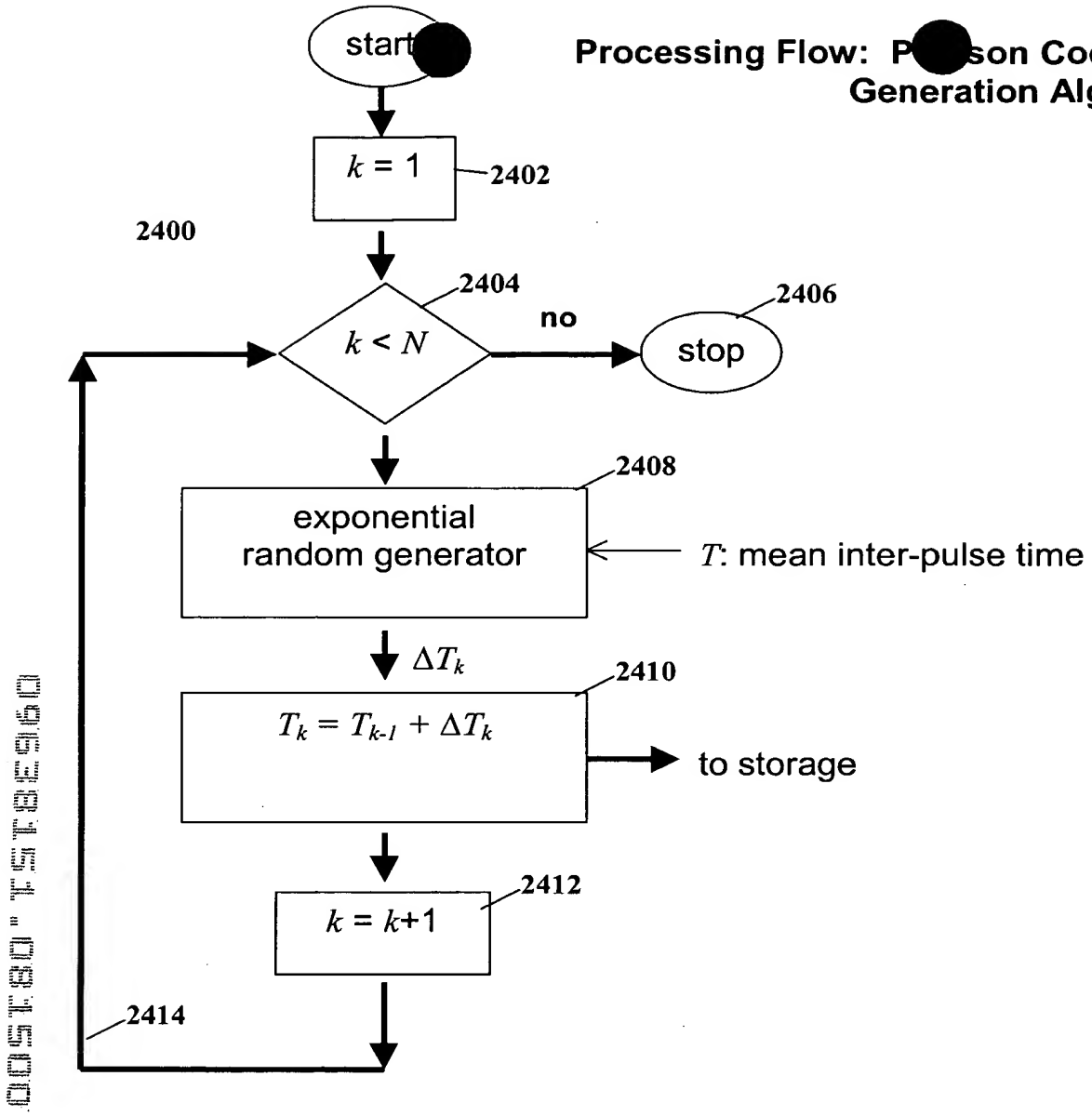

Processing Flow: Poisson Code Generation Algorithm
start
$k = 1$
2402
2400
2404
$k < N$
no
2406
stop
2408
exponential random generator
T: mean inter-pulse time
ΔT_k
2410
$T_k = T_{k-1} + \Delta T_k$
to storage
2412
$k = k+1$
2414

FIGURE 24

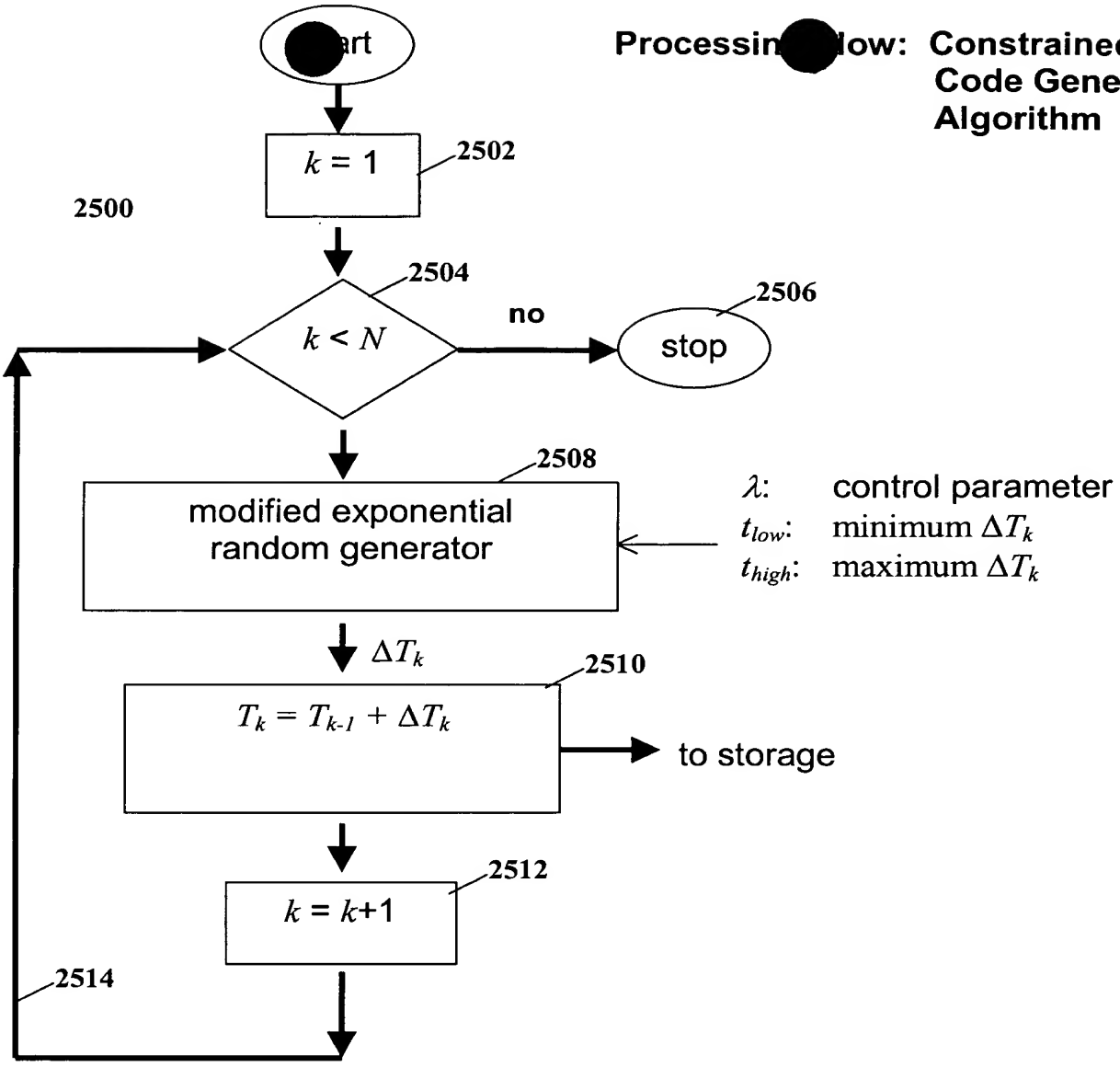

Processing Flow: Constrained Poisson Code Generation Algorithm
2500
start
k = 1
2502
2504
k < N
no
2506
stop
2508
modified exponential random generator
λ: control parameter
t_{low}: minimum ΔT_k
t_{high}: maximum ΔT_k
ΔT_k
2510
$T_k = T_{k-1} + \Delta T_k$
to storage
2512
k = k+1
2514

FIGURE 25

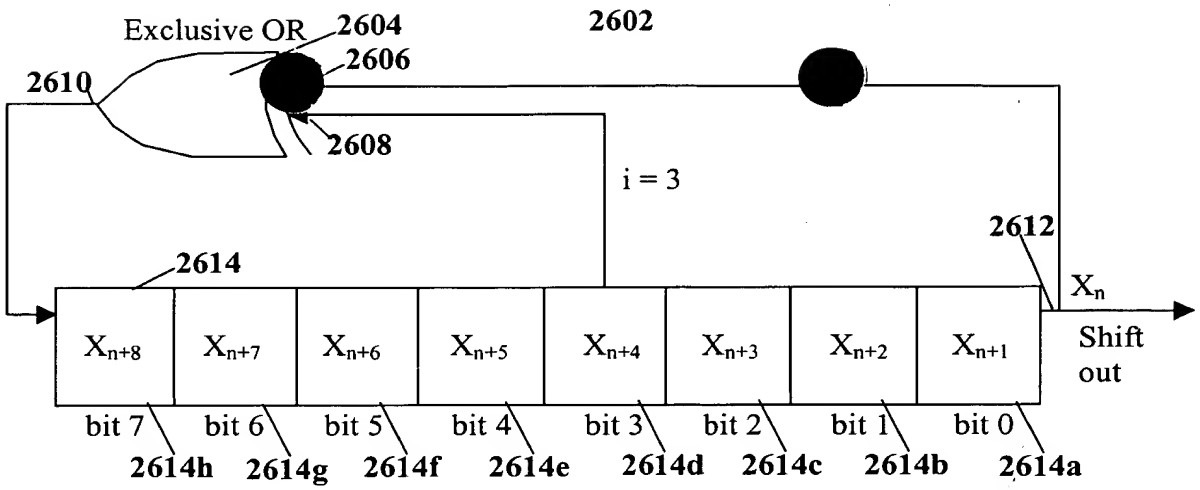


FIGURE 26a. Linear Feedback Shift Register

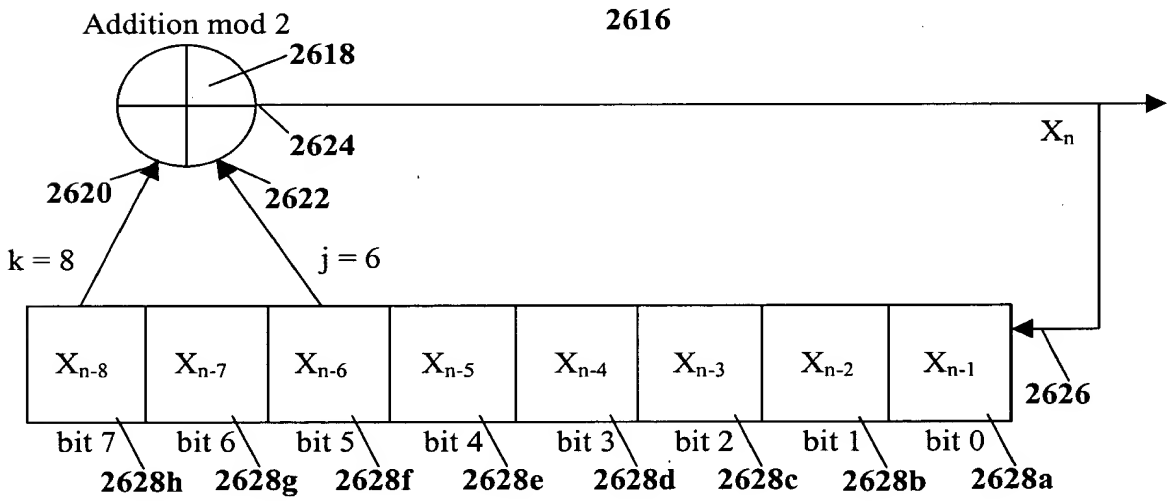


FIGURE 26b. Lagged-Fibonacci Shift Register Generator

Flow Diagram for Sequential Generation of Delta Codes

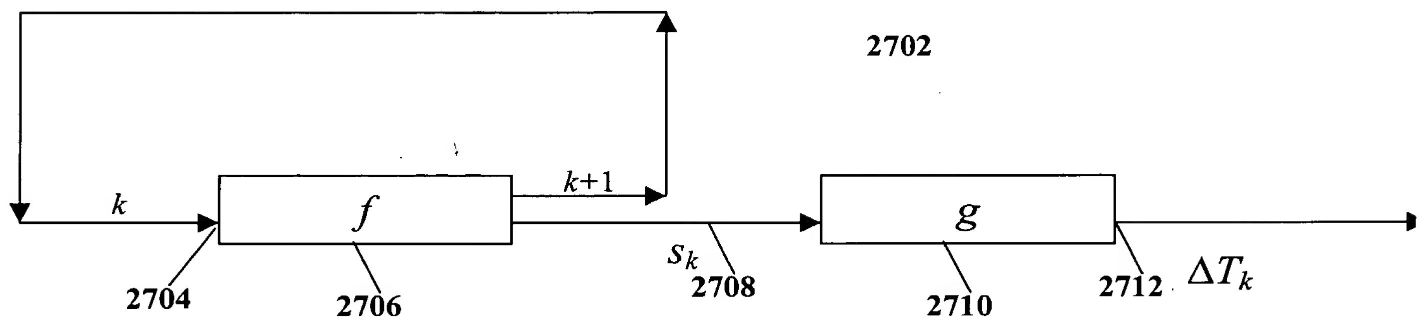


FIGURE 27

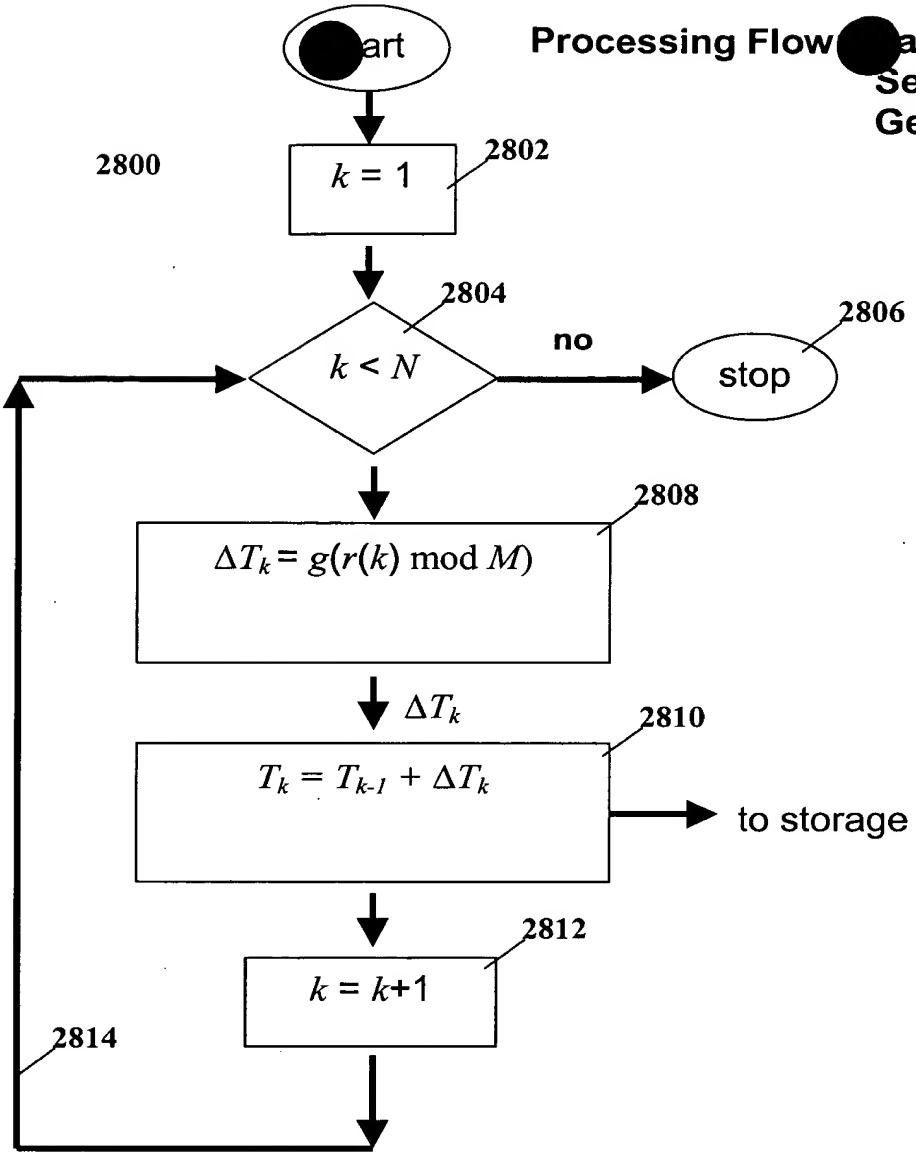

Start
Processing Flow for Rational Congruential Sequential Delta Code Generation Algorithm
2800
$k = 1$
2802
2804
$k < N$
no
2806
stop
2808
$\Delta T_k = g(r(k) \bmod M)$
ΔT_k
2810
$T_k = T_{k-1} + \Delta T_k$
to storage
2812
$k = k+1$
2814

FIGURE 28

Flow Diagram for Iterated Generation of Delta Codes

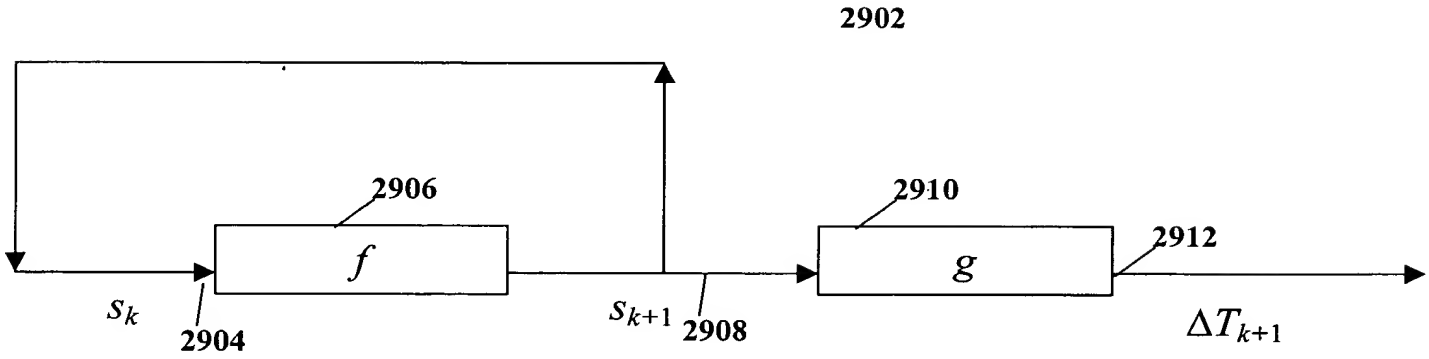


FIGURE 29

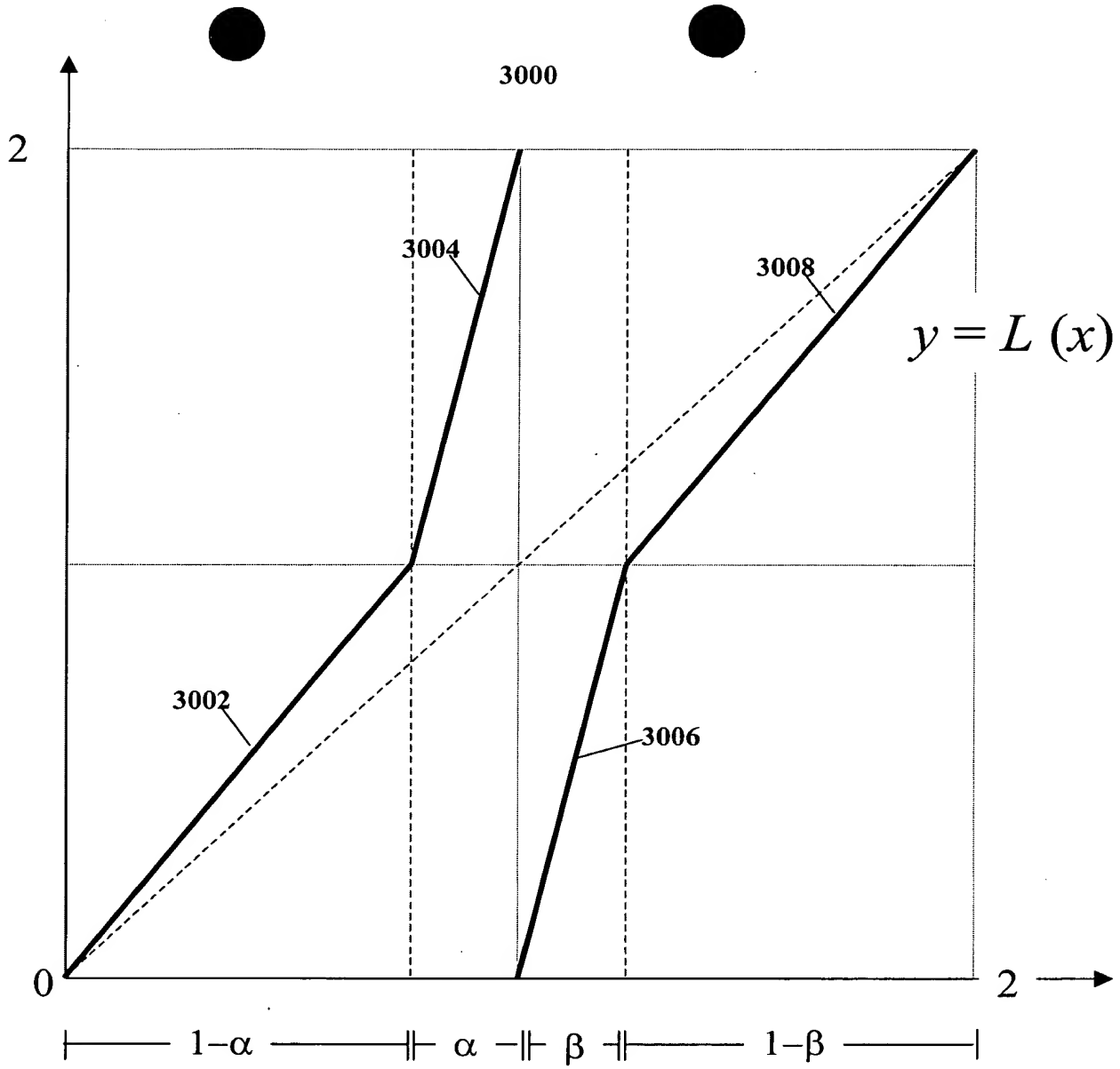


FIGURE 30

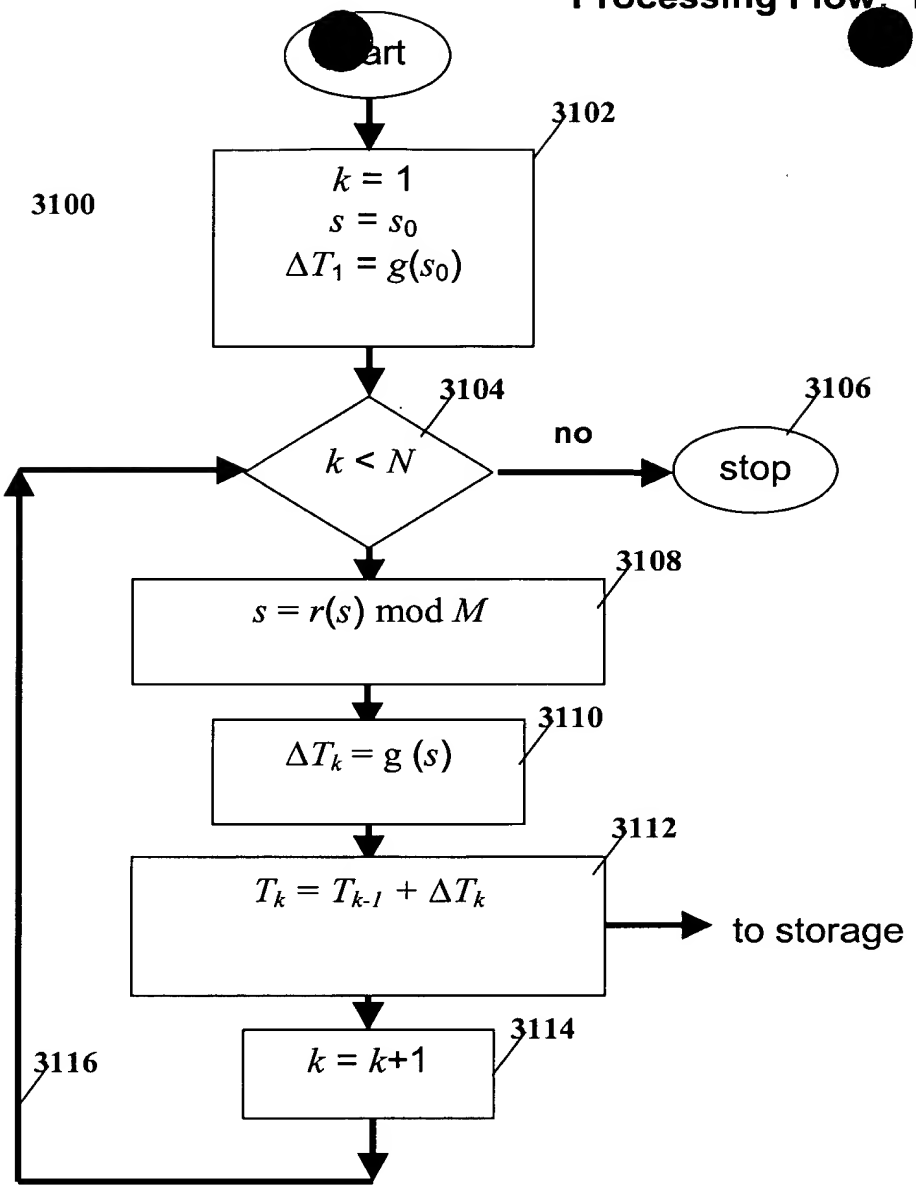

Processing Flow: Rational Congruential Iterative Delta Code Generation Algorithm
art
3100
3102
$k = 1$
$s = s_0$
$\Delta T_1 = g(s_0)$
3104
$k < N$
no
3106
stop
3108
$s = r(s) \bmod M$
3110
$\Delta T_k = g(s)$
3112
$T_k = T_{k-1} + \Delta T_k$
to storage
3114
$k = k+1$
3116

FIGURE 31

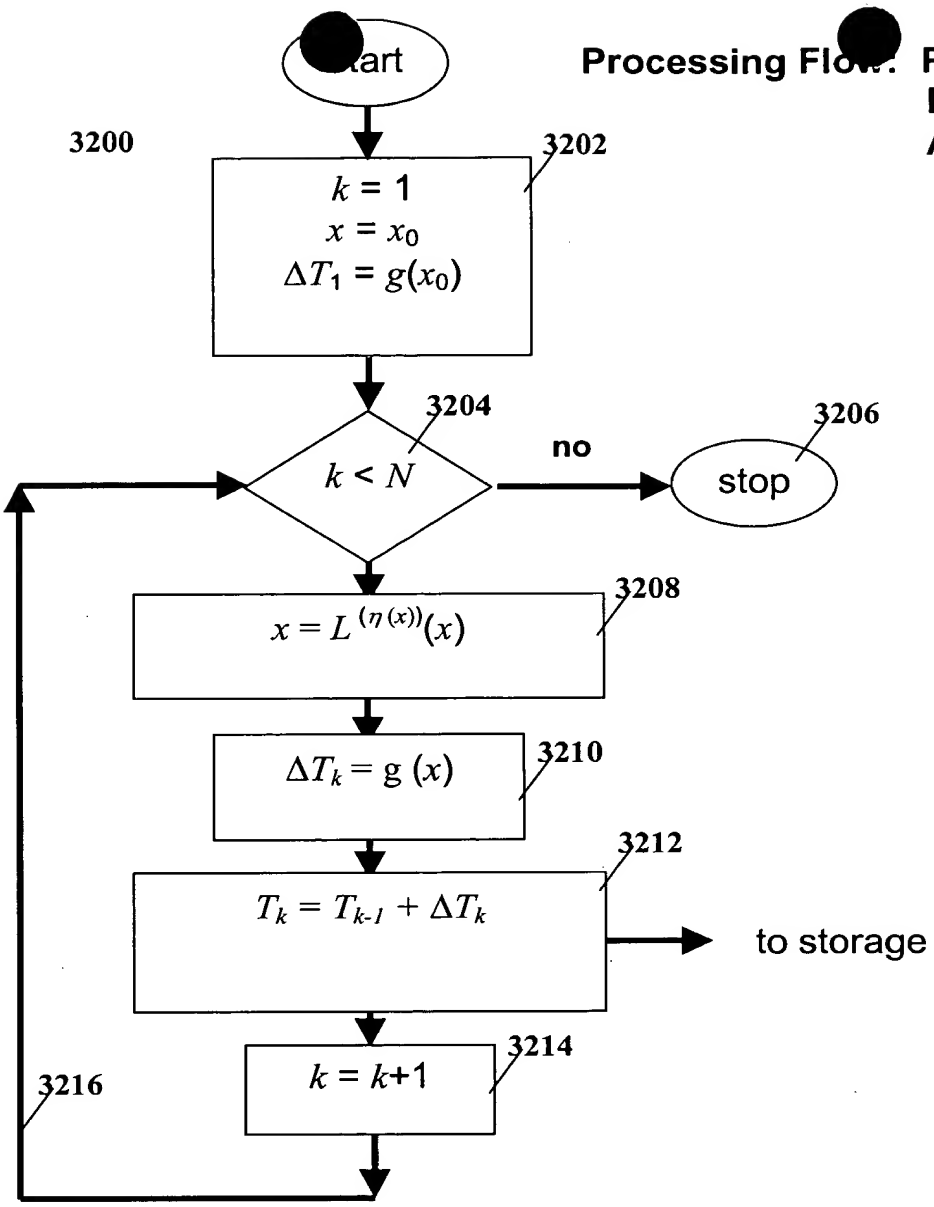

Start
Processing Flow: Piecewise Linear Iterative Delta Code Generation Algorithm
3200
3202
$k = 1$
$x = x_0$
$\Delta T_1 = g(x_0)$
3204
$k < N$
no
3206
stop
3208
$x = L^{(\eta(x))}(x)$
3210
$\Delta T_k = g(x)$
3212
$T_k = T_{k-1} + \Delta T_k$
to storage
3214
$k = k+1$
3216

FIGURE 32

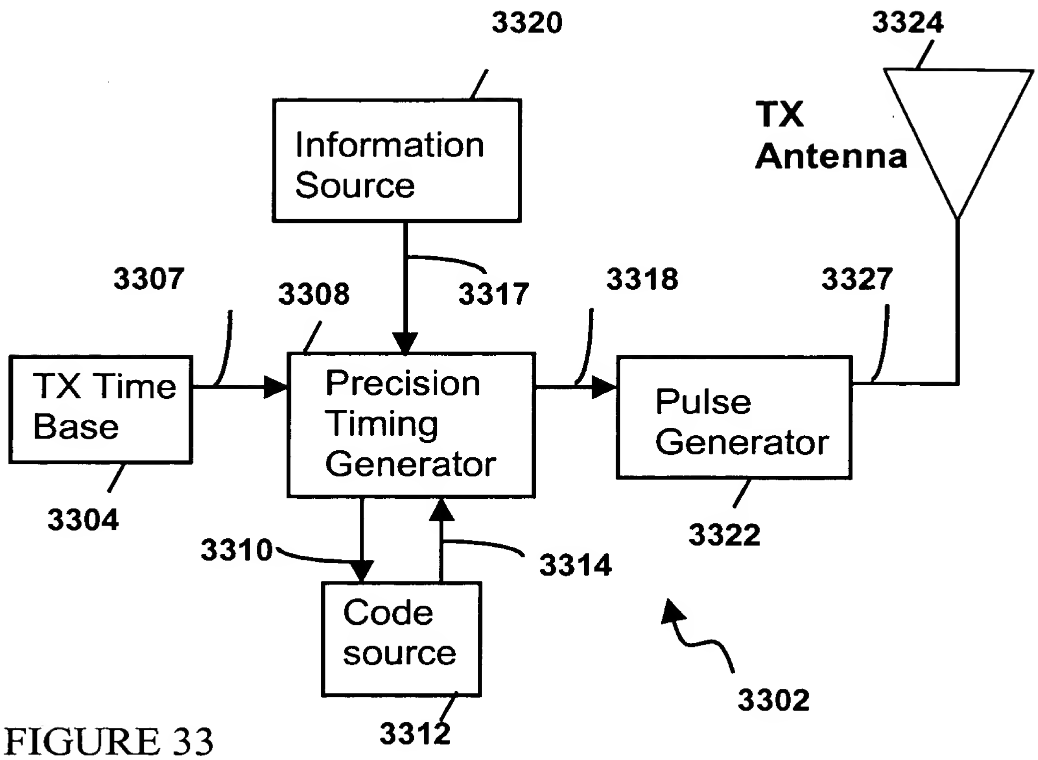
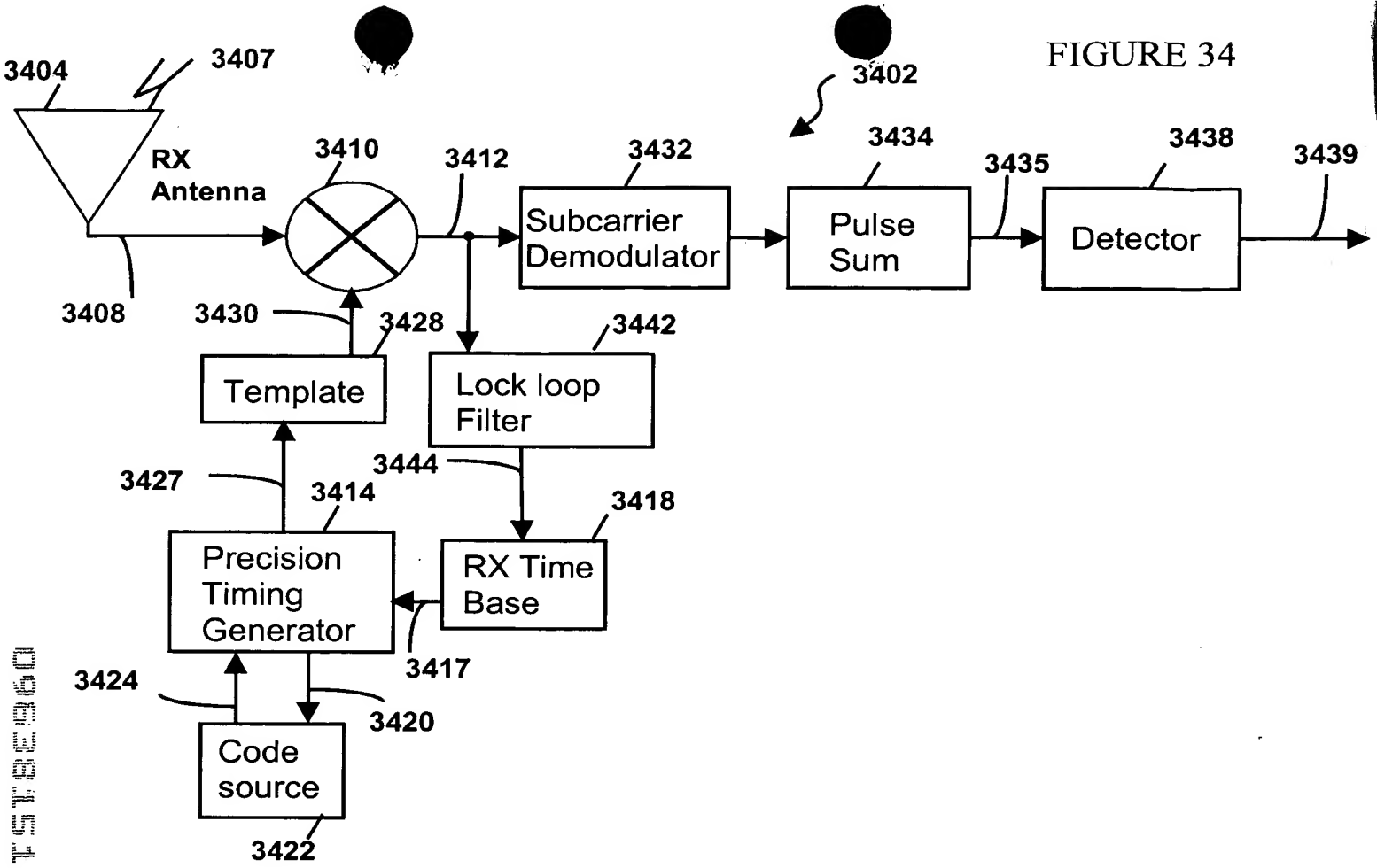


FIGURE 33

FIGURE 34


3404
3407
3402
RX
Antenna
3410
3412
3432
3434
3435
3438
3439
Subcarrier
Demodulator
Pulse
Sum
Detector
3408
3430
3428
3442
Template
Lock loop
Filter
3444
3427
3414
3418
Precision
Timing
Generator
RX Time
Base
3417
3424
3420
Code
source
3422